



# Record: an integrated framework to build, evaluate and simulate

Jacques-Eric Bergez, Frederick Garcia, Helene Raynal

## ► To cite this version:

Jacques-Eric Bergez, Frederick Garcia, Helene Raynal. Record: an integrated framework to build, evaluate and simulate. 11. ESA Congress, Aug 2010, Montpellier, France. 2010, Proceedings of Agro2010 - the XIth ESA Congress. hal-02752597

**HAL Id: hal-02752597**

**<https://hal.inrae.fr/hal-02752597>**

Submitted on 3 Jun 2020

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

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

J.-E. Bergez<sup>1</sup>, F. Garcia<sup>2</sup>, H. Raynal<sup>2</sup>  
<sup>1</sup>INRA UMR 1248 AGIR F-31326 Castanet;  
<sup>2</sup>INRA UBIA F-31326 Castanet;

## **Introduction**

The rapid change in the agricultural industry driven by continuously arising challenges requires the development of new methods of production in order to guarantee sustainable agriculture. In silico approaches, based on the study of a wide range of possible systems through modelling and simulation, offer the possibility of identifying more quickly new systems to tackle current social, political and environmental concerns (Bergez et al., 2010).

However, building, testing, evaluating, using models (i.e. simulating different scenarios of management, pedo-climate situation, and constraints) is far from being a straightforward task. Numerous models already exist dealing with plenty of questions regarding the agrosystem functioning. Nowadays one of the main issues is more how to couple them and how to use them at different spatial and temporal scales rather than developing new ones from scratch. Integrated assessment (Rotmans, 2009) is today key word of research projects. To help the French researcher community working on cropping systems development, the French National Research on Agronomy (INRA) set up a 4-year project to develop an integrated modelling framework to gather, link and provide models and companions tools to answer new society questions regarding agriculture.

The aim of this paper is to present the framework through some examples of uses. After a brief presentation of the specifications (functional and non functional) and of the chosen computing framework, we will provide different examples to enhance the strength of the approach and how new questioning may be tackled by using the RECORD environment.

## **Specifications**

Functional specifications were drawn during a two-day meeting in January 2007 (Bergez et al., 2007). About 50 French researchers working on cropping systems and using models to understand, analyse and develop cropping systems joined this meeting. Ideally, the computing framework should enable (short list):

- to develop new models as modular components, to re-use and combine them in order to represent cropping systems at different time and spatial integration steps;
- to allow the modelling and simulation of farmer's decision making process;
- to link with statistical packages to perform model calibration or in silico experiment analyses;
- to link with economics and optimization software and risk analysis;
- to link with databases and GIS;
- to include random weather generators to work on climate change and uncertainty

Based on these functional specifications, non functional specifications were developed (Chabrier and Raynal, 2007). Without getting in large details, software architecture, running platform, performances, programming languages, graphic user interfaces ... were analysed.

## **Computing choices**

After having analysed or tested different existing platform (CAPSIS, ModCom, Diese, Ptolemy II), or graphical modelling packages such as ModelMaker, Stella, Simile, the VLE core environment was chosen. VLE is based on the DEVS discrete event formalism of the Modeling and Simulation theory (Zeigler et al., 2000) and is a common framework (formal and operational) for the specification of dynamical systems. DEVS defines an atomic model as a set of input and output ports and a set of state transition functions. Every atomic model can be coupled with one or several other atomic models to build a coupled model. The set of atomic and coupled models and their connections forms the structure of the model. The VLE Virtual Laboratory Environment (Quesnel et al., 2009) is an original framework that can be used to model, simulate, analysis or visualize dynamics of complex systems. It is a free and open source software developed in C++. VLE is able to integrate specific models developed in most popular programming languages into one single multi-model. One can also create a model from scratch using the GUI and linking different submodels with ports.

## Examples

In order to give a flavour of the possibilities of the RECORD platform, we enumerate some examples of models currently developed by INRA agronomists:

- Providing essential cropping systems models, by encapsulating existing ones or by coding them directly into the platform: The STICS models (Brisson et al., 1998) which is a largely used cropping systems model in France has been integrated by encapsulation and made available for research on cropping systems; As for the SUNFLO model, it was coded within the RECORD environment to allow working on sunflower genetics;
- Linking decision and biophysical models to mimic action of farmers: the MO<sub>U</sub>STICS project links the STICS model to the generic decision model MODERATO (Bergez et al., 2001) in order to develop alternative crop management systems; a PhD work is also aimed at developing a generic atomic decision model for RECORD.
- Dynamically creating new entities: a crop acreage PhD work allowed to develop dynamic link with GIS database and to create at run time new plots with specified crop and crop management on it;
- Integrating pest in cropping systems management: A PhD is currently working on modelling the effects of spatially distributed cropping systems on the epidemics of potato late blight and on the durability of cultivar resistances (Aubertot et al, 2010); the WHEATPEST project (Soudais et al., 2010) enables quantifying individual and combined yield losses caused by a variety of pests on wheat(diseases, weeds and insects);
- Searching innovative cropping systems: optimisation algorithm such as P2P specifically developed to search optimal crop management systems have been integrated in RECORD; The MicMac design project aimed at integrating different models and approach to develop innovative cropping systems.
- Linking with statistical packages: extension allowing link to and from the statistical package R has been developed allowing model calibration, sensitivity analysis ...

## Conclusions

The building phase of the RECORD modelling framework is now over. Different research projects use the framework as a tool or even as an approach to reach their objectives. As developed models may be made available as package to the community, it is expected an exponential development use of the framework. Search, wait and see.

## References

- Aubertot et al., 2010. Modelling the effects of spatially distributed cropping systems on the epidemics of potato late blight and on the durability of cultivar resistances, ESA Conference 2010, Montpellier.
- Bergez et al., 2001. MODERATO: an object-oriented decision model to help on irrigation scheduling for corn crop. *Ecol. Model.* 137(1): 43-60.
- Bergez et al., 2007. Expression des besoins fonctionnels, Rapport Projet RECORD, N° 2007/1 - Juin 2007, Départements EA & MIA, INRA, 14 p.
- Bergez et al., 2010, Designing crop management systems by simulation. *Europ. J. Agronomy* 32: 3-9
- Chabrier, P., Raynal, H., 2007. Spécifications non fonctionnelles, Rapport Projet RECORD, N° 2007/2 – Juin 2007, Départements EA & MIA, INRA, 9 p.
- Brisson, et al., 1998. STICS: a generic model for the simulation of crops and their water and nitrogen balances. I. Theory and parametrization applied to wheat and corn. *Agronomie*, 18, 311-346
- Quesnel et al., 2009. The Virtual Laboratory Environment - An Operational Framework for Multi-Modelling, Simulation and Analysis of Complex Systems. *Simulation Modelling Practice and Theory* (17), 641-653.
- Rotmans J., 2009. Three decades of Integrated Assessment: the way forward. Introductory keynote paper, AgSAP Conference 2009, Egmond aan Zee, The Netherlands, 10-12 March 2009.
- Soudais et al., 2010. Evaluation of WHEATPEST, a model predicting wheat yield losses caused by an injury profile in a given production situation, ESA 2010 Conference, Montpellier.
- Zeigler et al.. 2000. Theory of modelling and simulation: Integrating discrete event and continuous complex dynamic systems. Academic Press.