Crop Monitoring as an E-agricultural tool in Developing Countries

REPORT ON BIOMA WORKSHOP

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TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

ACRONYMS & GLOSSARY

BioMA: a framework to run biophysical modelling solutions based on multi-approach components. The framework is based on three layers: (i) the model layer (where models are codified in software components with a fine level of granularity); (ii) the composition layer (where models and submodels codified in different components can be linked to build complex modelling solutions); (iii) composition layers (where modelling solutions can be provided with attributes to allow their run in complex applications). Each of these layers can be accessed to develop applications, that are usually simple in case they access directly the model layer, complex when the configuration layer is identified as the target one.

COMPONENT: a framework-specific unit of code implementing – with a fine level of granularity – alternate approaches for biophysical processes within the same domain (e.g., soil hydrology).

CROP MODEL: a series of equations and/or algorithms, mainly implemented in a computer program, that reproduce the growth and development of crops. Data on weather, soil, and crop management are processed to predict information like, e.g., crop yield, maturity date, efficiency of fertilizers and other elements of crop production. Algorithms implemented in crop models are based on the existing knowledge on physiological, physical and ecological information on the way crops interact with environment.

CROPSYST: a generic crop simulator based on the concept of net photosynthesis, estimated on a daily basis as driven by potentially transpired water and absorbed photosynthetically active radiation.

MODELLING SOLUTION: a chain of models or submodels linked according to the objectives of a specific type of modelling study.

EXECUTIVE SUMMARY

Compared to other approaches, based on monolithic implementations of models, BioMA is a flexible, component-based platform for running biophysical models, able to support users in customizing the simulation environment according to the specific needs of each modelling study. In order to effectively transfer the platform to E-AGRI partners, dedicated workshops have been foreseen during the project.
The first BioMA workshop was organized in Nanjing (People's Republic of China), during 10-12 December 2012. The workshop focused on the presentation of the main concepts behind BioMA, on some related technical aspects, and on a practical training performed with the BioMA modelling solution represented by the CropSyst model for crop growth and development of rice in Jiangsu. The workshop revealed a good degree of satisfaction for participants, and gave to the trainers important indications on how to organize the following events. The second BioMA workshop was organized in Rabat (Morocco), during 19-21 March 2013. The workshop focused on the discussion of the main characteristic of the Moroccan wheat system, on the possibility to include in the modelling solution a component for the simulation of diseases, and on the practical training with the BioMA modelling solution represented by the CropSyst model for crop growth and development linked to a cascading approach for soil water redistribution. The third BioMA workshop was organized in Milano (Italy), during 9-13 December 2013. Here the focus was on yield forcasting based on the multi-model simulation of wheat in Morocco including the component for disease impact, and on the dissemination of technical skill for the implementation of automated agromanagement events within the BioMA modelling solution.

1. Introduction

BioMA is a platform for running biophysical modelling solutions explicitly built for specific simulation studies. Compared to other approaches, based on monolithic implementations of models, BioMA gives the possibility of defining modelling configurations by including or excluding *modules* for the simulation of aspects (e.g., interaction between crops and pathogens) that can be of interest under certain conditions, thus allowing modellers to increase the degree of adherence of the simulated sistems to the underlying ones.
The other side of the coin of such a flexibility is represented by the need of specific skills and of a deeper knowledge on models and on the conditions explored.
This is why a series of dedicated workshops have been foreseen during the E-AGRI project, to properly transfer concepts and technology related to this platform.

1.1. Contents of the deliverable

In this report, we provide a report of each of the BioMA workshops organized during the project:

(i) 1st BioMA workshop (Nanjing, People's Republic of China, 10-12 December 2012).
(ii) 2nd BioMA workshop (Rabat, Morocco, 19-21 March 2013)
(iii) 3rd BioMA workshop (Milano, Italy, 9-13 December 2013)

2. E-AGRI BioMA workshops

All the BioMA workshops are organized with

- a first part, where theoretical concepts related to platform potentialities, structure and technology are presented, and
- a second part, represented by a practical training focusing on one of the different modelling solutions implemented in the platform.

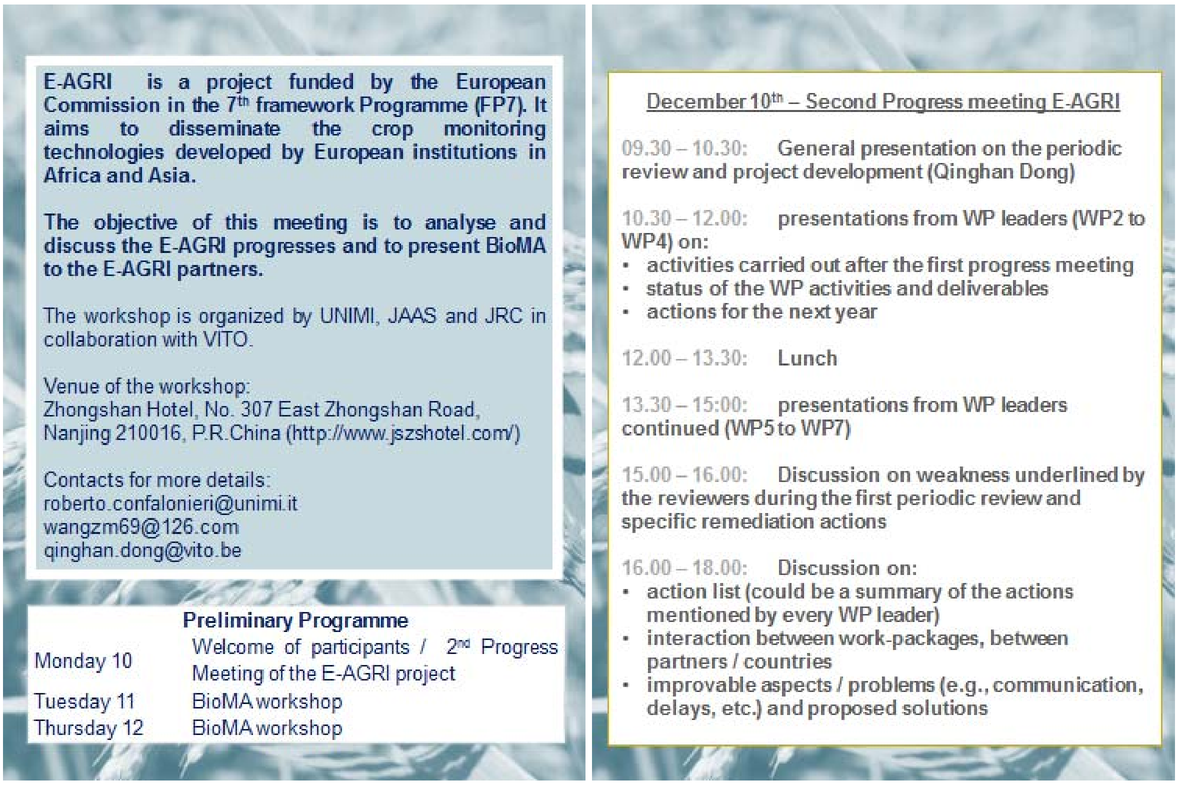
2.1. 1st BioMA workshop

The first BioMA workshop took place in Nanjing, People's Republic of China during 10-12 December 2012, and it was coorganized by Nanjing Academy of Agricultural Sciences (JAAS) and University of Milan (UMIL).

2.1.1. Agenda

The flier of the meeting, together with a detailed agenda, is presented in Figures from 1 to 3.
Contrarily to what is present in the original meeting agenda, Dr. Marcello Donatelli could not attend the meeting, and his presentations were given by Dr. Roberto Confalonieri (co-author of the presentations and of the BioMA platform).

Figure 1: Agenda of the 10-12 December 2012 E-AGRI meeting, where the 1st BioMA workshop was organized. First page



E-AGRI is a project funded by the European Commission in the 7th framework Programme (FP7). It aims to disseminate the crop monitoring technologies developed by European institutions in Africa and Asia.

The objective of this meeting is to analyse and discuss the E-AGRI progresses and to present BioMA to the E-AGRI partners.

The workshop is organized by UNIMI, JAAS and JRC in collaboration with VITO.

Venue of the workshop:
Zhongshan Hotel, No. 307 East Zhongshan Road, Nanjing 210016, P.R.China (http://www.jszshotel.com/)

Contacts for more details:
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Preliminary Programme

Monday 10	Welcome of participants / 2nd Progress Meeting of the E-AGRI project
Tuesday 11	BioMA workshop
Thursday 12	BioMA workshop

December 10th – Second Progress meeting E-AGRI

09.30 – 10.30: General presentation on the periodic review and project development (Qinghan Dong)

10.30 – 12.00: presentations from WP leaders (WP2 to WP4) on:
- activities carried out after the first progress meeting
- status of the WP activities and deliverables
- actions for the next year

12.00 – 13.30: Lunch

13.30 – 15:00: presentations from WP leaders continued (WP5 to WP7)

15.00 – 16.00: Discussion on weakness underlined by the reviewers during the first periodic review and specific remediation actions

16.00 – 18.00: Discussion on:
- action list (could be a summary of the actions mentioned by every WP leader)
- interaction between work-packages, between partners / countries
- improvable aspects / problems (e.g., communication, delays, etc.) and proposed solutions

Figure 2: Agenda of the 10-12 December 2012 E-AGRI meeting, where the 1st BioMA workshop was organized. Second and third pages

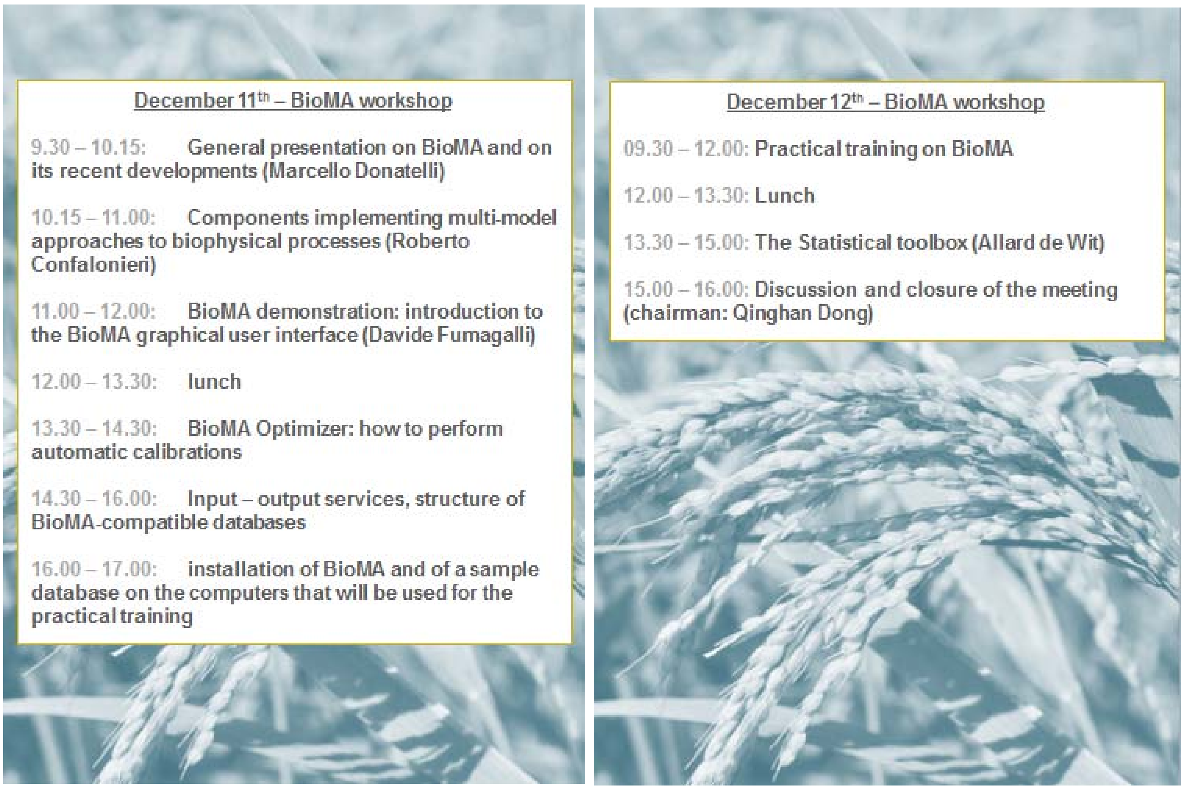

Figure 3: Agenda of the 10-12 December 2012 E-AGRI meeting, where the 1st BioMA workshop was organized. Fourth and fifth pages

2.1.2. Participants

Participants to the first BioMA workshop are presented in Table 1 and Figure 4.

Table 1: Participants to the first BioMA workshop

Name	Organization	e-mail
Dong Qinghan	Flemish Institute for Technological Research (VITO), Belgium	qinghan.dong@vito.be
Roberto Confalonieri	Department of Agricultural and Environmental Science, University of Milan (UMI), Italy	roberto.confalonieri@unimi.it
Caterina Francone	Department of Agricultural and Environmental Science, University of Milan (UMI), Italy	caterina.francone@unimi.it
Giovanni Cappelli	Department of Agricultural and Environmental Science, University of Milan (UMI), Italy	giovanni.cappelli@unimi.it

Allard de Wit	Alterra, Wageningen (SDLO) – UR, Netherlands	Allard.dewit@wur.nl
Henry Proimen	Department of Resource Surveys and Remote Sensing (DRSRS), KENYA	hproimen@yahoo.com
Riad BALAGHI	Institut National de la Recherche Agronomique (INRA), Maroc	riad.balaghi@gmail.com
Sliman El Hani	Institut National de la Recherche Agronomique (INRA), Maroc	sliman_elhani@yahoo.fr
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Shan Jie	Institute of Agricultural Economics and Information, Jiangsu Academy of	owsj1986@sina.com

	Agricultural Sciences (JAAS), China	
Mao Liangjun	Institute of Agricultural Economics and Information, Jiangsu Academy of Agricultural Sciences (JAAS), China	maoliangjunalan@163.com

Figure 4: Participants to the first BioMA workshop

2.1.3. Presentations and practical training

The theoretical part of the workshop focused on two presentations:

- the first one [Appendix A] was on the general conceptual and technological issues behind BioMA, and
- the second one [Appendix B] on the multi-model components available for the simulation of biophysical processes within different domains.

After participants had installed the BioMA application, database and related drivers on their laptops with the support of the trainers, the practical training focused on configurating and running – under BioMA and by changing parameters and configuration items – a modelling solution based on the CropSyst model (Stöckle et al., 2003[1]) for crop

[1] Stöckle, C.O., Donatelli, M., Nelson, R., 2003. CropSyst, a cropping systems simulation model. European Journal of Agronomy, 18, 289-307.

growth and development under potential and water limited conditions, linked to a cascading approach for soil water redistribution. In the specific training, rice in the Jiangsu province was simulated.
The training was organized with one trainer making the exercises by working on a computer linked to a projector, and with other two trainers supporting participants while repeating the exercises on their laptops.
During the training, different configuration and parameterization options were tested, and simulation results were discussed.

2.1.4. Feedbacks and improvements for next workshops and trainings

At the end of the workshop and of the practical training, positive feedbacks were received from all participants.
However, after the meeting was concluded, it was decided to prepare – for the 2013 workshops – a specific questionnaire to evaluate the level of satisfaction of participants, in order to collect feedbacks in a more rigorous and, thus, to increase the training effectiveness for the following BioMA workshops. The questionnaire prepared is presented in Appendix C.

2.2. 2nd BioMA workshop

The 2nd BioMA workshop was organized in Rabat (Morocco) from the 19th to the 21st March 2013, with the aim to effectively favor the WP34 activities. The workshop was coorganized by Institut National de la Recherche Agronomique (INRA) and University of Milan (UMIL).

2.2.1. Agenda

The flier and the agenda of the meeting are presented in Figure 5.

Figure 5: Agenda of the second BioMA workshop

2.2.2. Participants

Participants to the second BioMA workshop are presented in Table 2 and Figure 6.

Table 2: List of participants to the second BioMA workshop

Name	Organization	e-mail
Riad BALAGHI	Institut National de la Recherche Agronomique (INRA), Maroc	riad.balaghi@gmail.com
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Sanae Krimi Bencheprouns	Institut National de la Recherche	krimisanae@gmail.com

	Agronomique (INRA), Maroc	
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Giovanni Cappelli	Department of Agricultural and Environmental Science, University of Milan (UMI), Italy	giovanni.cappelli@unimi.it
Valentina Pagani	Department of Agricultural and Environmental Science, University of Milan (UMI), Italy	valentina.pagani2@studenti.unimi.it
Simone Bregaglio	Department of Agricultural and Environmental Science, University of Milan (UMI), Italy	simone.bregaglio@unimi.it
Fabien Ramos	Joint Research Centre of the European Commission (JRC), Italy	fabien.ramos@jrc.ec.europe.eu
Tahri Mostafa	Direction de la Stratégie et des Statistiques (DSS), Maroc	tahrimostafa@gmial.com

Figure 6: Participants of the second BioMA workshop

2.2.3. Presentations and practical training

During the first day of the workshop two presentations about the calibration of the models (state of the Morocco calibration activities) and the potentiality of the model-based forecasting system guided the discussion. As highlighted in the minutes of the meeting (see Appendix D), the heterogeneity of the expertizes allowed the identification of the main actions still needed within the WP34 and inspired further collaboration beyond E-AGRI objectives. Main attention was devoted to the importance of the diseasis impacts on Moroccan cropping system and to the possibility to include this effect on the BioMA modelling solution.

Figure 7: Participants of the second BioMA workshop during the first day of the meeting

The BioMA training organized in the 3rd day of the meeting was focused on the spatially distributed simulations on the Moroccan wheat areas, by changing management and parameter set with the aim to reproduce the different crop varieties of the country.

Figure 8: Participants of the second BioMA workshop during the training

2.2.4. Feedbacks and improvements for next workshops and trainings

The participant satisfaction was evaluated by submitting the questionnaire prepared during the second year of the project (see Appendix C). An e-mail was sent during the last day of the workshop to all participants and about the 50% of them replayied within few days. A summary of the results is represented in Table 3.

Table 3: Results of the questionnaire filled by a participant sample of the 2nd BioMA workshop

Compared with expectations		Below	Met	Above
Event preparation	Programme	1	3	2
	Objectives		4	2
	Selection of speaker		2	4
Event's delivery	Contents/quality of presentations		3	3
	Discussion time / interaction among participants		2	4
	Workshops / sub-sessions		3	3
	Balance among sections		4	2
	Speakers' performance		1	5
	Supporting material	1	2	3
Organization, Logistics	Organization, location, communication with participants, side events		1	5
Content	Training capacity to meet your learning objectives and its relevance for your work	1	4	1
	Quality and accuracy of contents		3	3
Methodology	Length of the course and balance between theory and practice	3	2	1
	Possibility of interaction with trainers and other participants		2	4
Learning resources	Usefulness and usability of course material / presentations		3	3
	Provision of additional resources (links, downloads, contacts)		1	4
Trainer / Facilitator	Trainers' communication and interaction		2	4
	Trainers' knowledge of the topic			6
General comments	Overall evaluation of the training		3	3
	Additional comments			

Generally, the evaluation was positive with most of the topic matching above the participant expectations.
Based on the results, the main concern was about the leght of the workshop, as highlighted by the two additional comments:

- *The time devoted for training was not enough, I would prefer at least one week for this event.*
- *The period allowed for the training is too short to achieve some practical issues related to models that are not included in CGMS.*

2.3. 3rd BioMA workshop

The third BioMA workshop took place in Milano (Italy) during 9-13 December 2013 and it was organized by University of Milan (UMIL).

2.3.1. Agenda

The detailed agenda of the 3rd BioMA workshop is presented in Table 4. As can be noted, the workshop started with a practical training on the use of the complete version of BioMA optimized for the Moroccan area, followed by a theoretical insight on agromanagement modelling and by a technical example on how to use the modelling environment and language.

Table 4: Agenda of the 3rd BioMA workshop

Monday 9th December
10.30-12.30 am: welcome at the University and installation of BioMA-Morocco on the laptops
2:00-4:00 pm: brief overview on BioMA user interface
4:00-6:00 pm: training on BioMA for wheat monitoring and forecasting in Morocco (performing simulations, changing options in the modelling solution)
Tuesday 10th December
training on BioMA for wheat monitoring and forecasting in Morocco (changing agromanagement rules/impacts, making forecasts, region-specific forecasts)
Wednesday 11th December
10:00-12:00 am: extending the parameterization of the diseases component for new pathogens
2:00-4:00 pm: overview on the AgroManagement concepts and on the rule/impact approach and formalizing an agromanagement event (e.g., for sowing specific for limiting the risk of Hessian fly attacks)
4:00-6:00 pm: implementation of a new rule for sowing date (based on rainfall and soil water content) by extending BioMA via the AgroManagement component
Thursday 12th December
morning: implementation of the new rule by extending BioMA via the AgroManagement component (conclusion)
afternoon: testing the BioMA multi-model approach to wheat monitoring and yield forecasts in Morocco using the new rule and comparing results with those achieved using other management rules
Friday 13th December
morning: discussion, questions and doubts on BioMA-Morocco and on possible extension to other processes and/or crops
afternoon: discussion on further collaborations (beyond E-AGRI) between University of Milan, the BioMA consortium and INRA-Morocco

2.3.2. Participants

Based on the suggestions derived by the 2nd workshop (see Table 3), the length of the BioMA workshop was increased (i.e., one week). Unlike the previous ones, the list of participants was decidedly shorter:

1. Ismaili Samira (Institut National de la Recherche Agronomique, Maroc);
2. Tarik El Hairech (Direction de la Météorologie Nationale, Maroc)

As a consequence, the ratio trainer to attender was close to one easing – among others – the fruition of the workshop.

2.3.3. Presentations and practical training

The first part of the workshop focused on the practical use of the BioMA application completely adapted to the Moroccan area. The last version of the BioMA was installed on the participant laptop, together with the CGMS statistical tool and the Visual Studio programming environment. The whole workflow of the forecasting system implemented in BioMA was presented. Some examples of modelling solution made by linking the growth and developments CropSyst or Wofost models with the diseasis component were supplied. The second part of the workshop was divided in (i) a theoretical presentation about modelling agricultural management rule, and (ii) a technical introduction of the agromanagement component with the implementation of a sowing rule appropriate for the Moroccan environment (i.e., based on rainfall and the soil water content). A tutorial was prepared to support the autonomous implementation an agromanagement rule thus allowing user interested in extending the AgroManagement component (see Appendix E for the whole guide).

Appendix F reports the minutes of the final discussion of the workshop.

2.3.4. Feedbacks

The questionnaire about the BioMA training evaluation (see Appendix C) was filled by both participants. Table 5 shows that the participants were highly satisfied with the whole trainitng, in particular about the accuracy of the contents and the trainer performances.

Table 5: Results of the questionnaire filled by the participants of the 3rd BioMA workshop

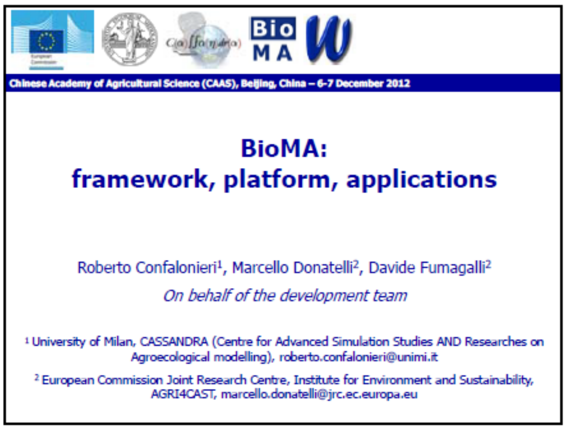
Compared with expectations		Below	Met	Above
Event preparation	Programme		1	1
	Objectives		1	1
	Selection of speaker			2
Event's delivery	Contents/quality of presentations		1	1
	Discussion time / interaction among participants		1	1
	Workshops / sub-sessions		1	1
	Balance among sections		1	1
	Speakers' performance			1
	Supporting material		1	1
Organization, Logistics	Organization, location, communication with participants, side events			2
Content	Training capacity to meet your learning objectives and its relevance for your work		1	
	Quality and accuracy of contents			2
Methodology	Length of the course and balance between theory and practice		1	1
	Possibility of interaction with trainers and other participants			2
Learning resources	Usefulness and usability of course material / presentations		1	1
	Provision of additional resources (links, downloads, contacts)			1
Trainer / Facilitator	Trainers' communication and interaction			2
	Trainers' knowledge of the topic			2
General comments	Overall evaluation of the training		1	1
	Additional comments			

3. Conclusions

The first BioMA workshop allowed to effectively transfer the main conceptual and technical aspects behind the BioMA platform.
Participants understood and appreciated the potentialities of the platform and its novel approaches. Although such potentialities and the advanced technical features slightly increase the complexity for the user compared to classical tools, the efforts invested in designing and developing the graphical user interface led to a friendly environment, that did not create problems or obstacles to the training participants.
During the second workshop the focus was mainly shifted on the flexibility of the modelling solution as the user intend to customize it for a more reliable reproduction of the system under analysis. Moreover, the link of the diseasis component to the growth and development models was discussed, evaluating both the adherence to the real system (i.e., which are the prevailing pathogens) and the benefits a forecasting system would take advantage.
The third workshop was an in-depth training about the use of the BioMA platform, including the actual customization of the platform for the simulation of (i) local management practices and (ii) diseases impact on yield production. Examples of pathogen parameterizations and management component extension (by adding new rules for sowing events) were effectively supplied to the participants.
A similar training will be recordered and uploaded on-line for the partners that did not attend the live workshop.

4. Appendix A

BioMA: framework, platform, applications


Bio
MA
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
BioMA:
framework, platform, applications
Roberto Confalonieri1, Marcello Donatelli2, Davide Fumagalli2
On behalf of the development team
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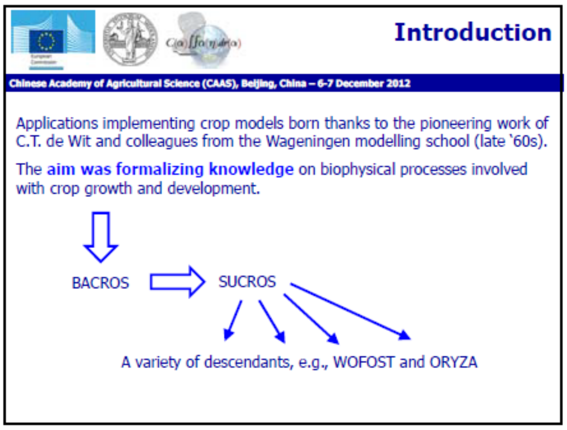
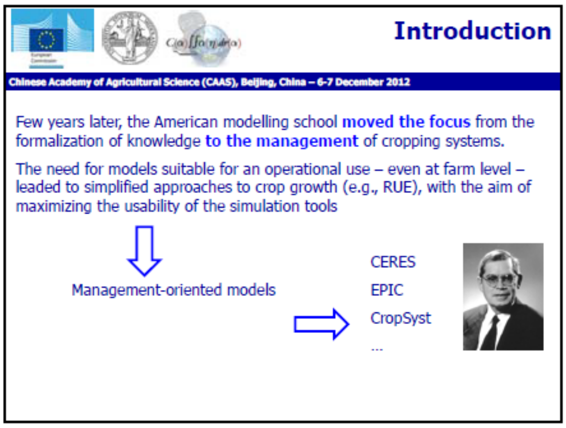
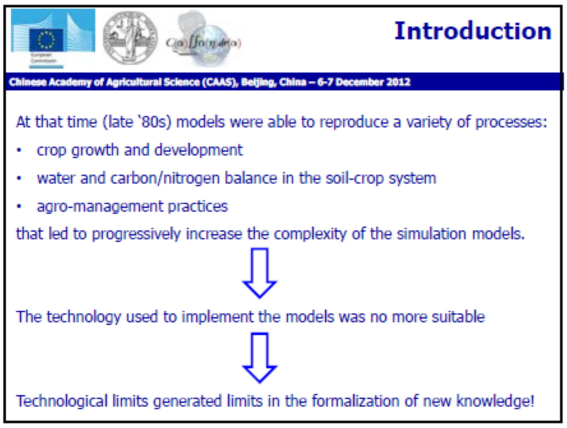
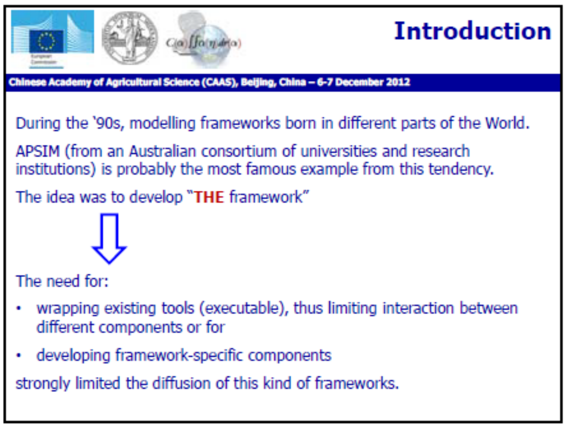
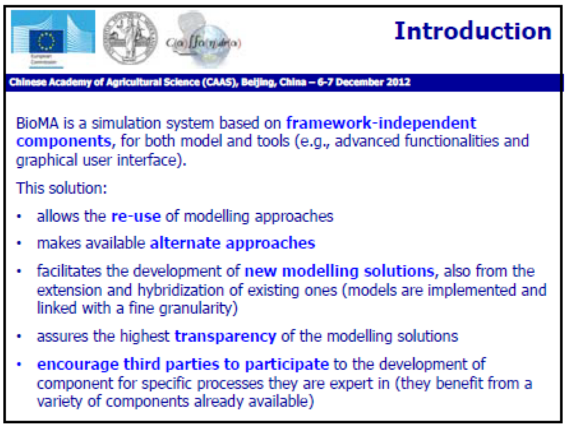
2 European Commission Joint Research Centre, Institute for Environment and Sustainability, AGRI4CAST, marcello.donatelli@jrc.ec.europa.eu


Introduction
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Applications implementing crop models born thanks to the pioneering work of C.T. de Wit and colleagues from the Wageningen modelling school (late '60s).
The aim was formalizing knowledge on biophysical processes involved with crop growth and development.
BACROS
SUCROS
A variety of descendants, e.g., WOFOST and ORYZA

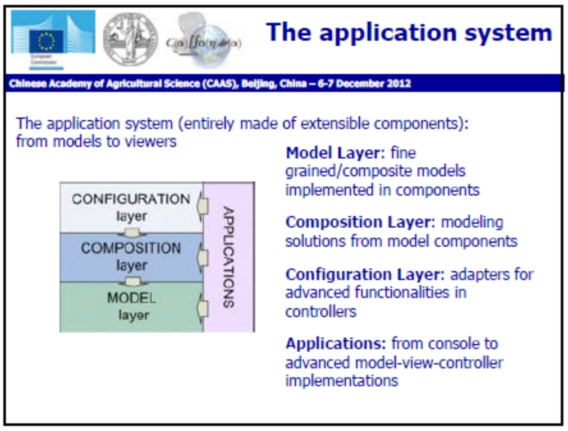

Introduction
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Few years later, the American modelling school moved the focus from the formalization of knowledge to the management of cropping systems.
The need for models suitable for an operational use – even at farm level – leaded to simplified approaches to crop growth (e.g., RUE), with the aim of maximizing the usability of the simulation tools
Management-oriented models
CERES
EPIC
CropSyst
...

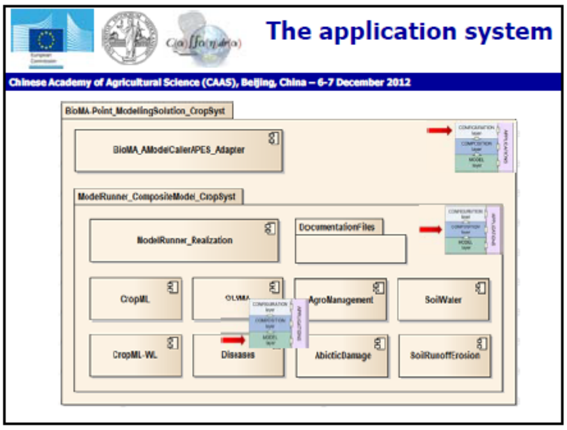

Introduction
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
At that time (late '80s) models were able to reproduce a variety of processes:
• crop growth and development
• water and carbon/nitrogen balance in the soil-crop system
• agro-management practices
that led to progressively increase the complexity of the simulation models.
The technology used to implement the models was no more suitable
Technological limits generated limits in the formalization of new knowledge!

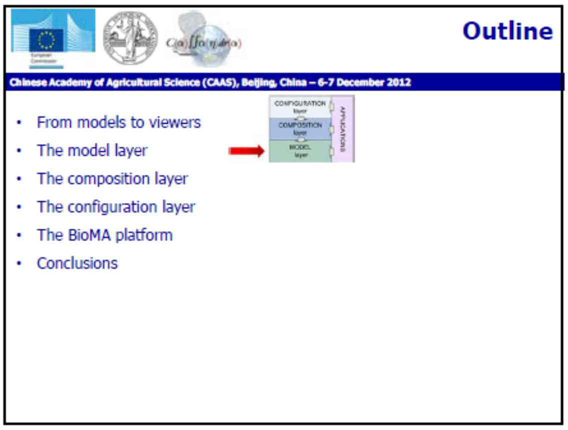

Introduction
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
During the '90s, modelling frameworks born in different parts of the World.
APSIM (from an Australian consortium of universities and research institutions) is probably the most famous example from this tendency.
The idea was to develop "THE framework"
The need for:
• wrapping existing tools (executable), thus limiting interaction between different components or for
• developing framework-specific components
strongly limited the diffusion of this kind of frameworks.


Introduction
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
BioMA is a simulation system based on framework-independent components, for both model and tools (e.g., advanced functionalities and graphical user interface).
This solution:
• allows the re-use of modelling approaches
• makes available alternate approaches
• facilitates the development of new modelling solutions, also from the extension and hybridization of existing ones (models are implemented and linked with a fine granularity)
• assures the highest transparency of the modelling solutions
• encourage third parties to participate to the development of component for specific processes they are expert in (they benefit from a variety of components already available)


Outline
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
• From models to viewers
• The model layer
• The composition layer
• The configuration layer
• The BioMA platform
• Conclusions


The application system
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
The application system (entirely made of extensible components): from models to viewers
CONFIGURATION layer
COMPOSITION layer
MODEL layer
APPLICATIONS
Model Layer: fine grained/composite models implemented in components
Composition Layer: modeling solutions from model components
Configuration Layer: adapters for advanced functionalities in controllers
Applications: from console to advanced model-view-controller implementations


The application system
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
BioMA-Point_ModellingSolution_CropSyst
BioMA_AModelCallerAPES_Adapter
ModelRunner_CompositeModel_CropSyst
ModelRunner_Realization
DocumentationFiles
CropML
AgroManagement
SoilWater
CropML-WL
Diseases
AbioticDamage
SoilRunoffErosion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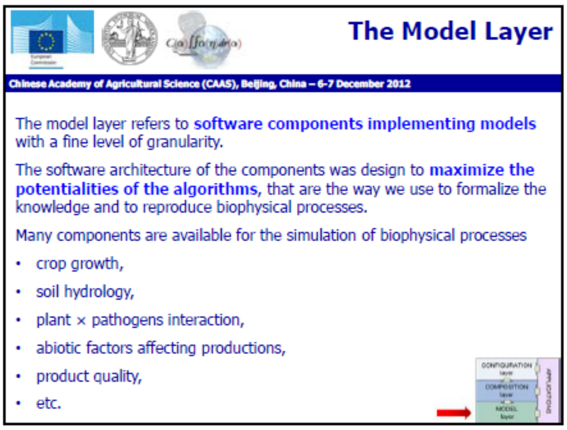
The Model Layer
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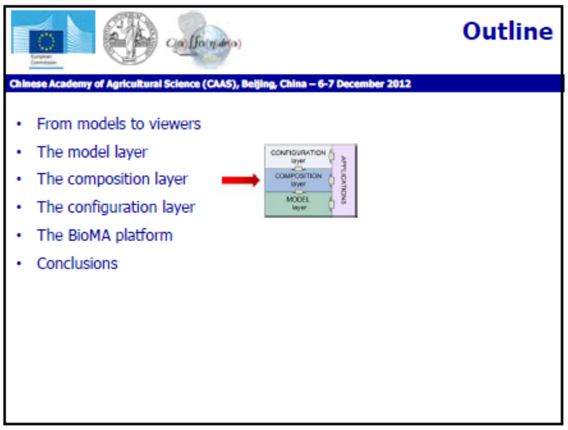
The model layer refers to software components implementing models with a fine level of granularity.
The software architecture of the components was design to maximize the potentialities of the algorithms, that are the way we use to formalize the knowledge and to reproduce biophysical processes.
Many components are available for the simulation of biophysical processes
• crop growth,
• soil hydrology,
• plant × pathogens interaction,
• abiotic factors affecting productions,
• product quality,
• etc.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Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
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The Composition Layer

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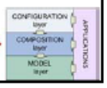
The composition layer must include:

- Communication across components
- Time handling
  - Communication time step
  - Time step of the different modelling approaches
- Events handling (for actions triggered not at all time steps)

The composition layer may include:

- Data services
- Visual tools for supporting composition



The Composition Layer

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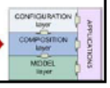
Requirements:

- Allow re-use of component data-types
- Allow transfer of modelling/run options to/from the higher level (Configuration layer, Application)
- Require simple implementation of component adapters to an instance of the layer (CLIC application – code generation)
- Allow multiple exchange of data across components within time step
- Have its own scalable logging
- Allow discovering (via reflection) components used and links
- Allow discovering inputs, outputs, parameters, and modelling options



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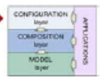

The Configuration Layer

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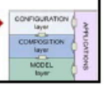
The data to run a modelling solution can originate from **various deployment environment**, for example using different databases, xml files, or remote web services.

A **specific view on data** given by an application **requires specific information** to allow user interaction according to the use cases needed.

All these ways of providing a modelling solution and a Graphical User Interface (GUI) with **needed data** are **abstracted** in the concept of a **configuration;** this concept is addressed in the Configuration Layer.

Also, **the configuration layer must expose handles** to run a modelling solution **iteratively,** as it is requested for instance in sensitivity analysis or when running automatic calibration/optimization.



The Configuration Layer

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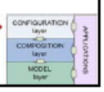
Requirements:

- Allow providing values for items constituting the configuration.
- Verify items validity with respect to the environment of execution.
- Save configuration for later reloading.
- Create recursive configuration structures, in case one of the items constituting the configuration needs in turn to be configured.
- Support callback functions when the status of a configuration changes, to refresh views attached in a Model View Controller architecture.



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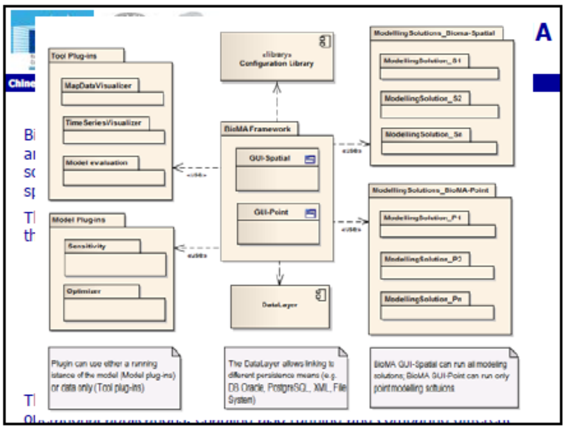
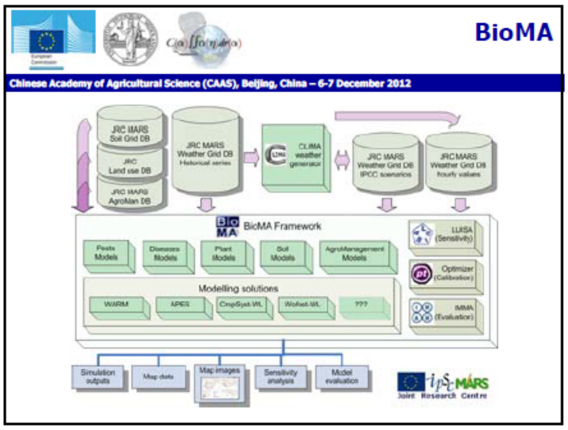

Tool Plug-ins
MapDataVisualizer
TimeSeriesVisualizer
Model evaluation
Model Plugins
Sensitivity
Optimizer
«library»
Configuration Library
BioMA Framework
GUI-Spatial
GUI-Point
DataLayer
ModellingSolutions_Bioma-Spatial
ModellingSolution_S1
ModellingSolution_S2
ModellingSolution_Sn
ModellingSolutions_BioMA-Point
ModellingSolution_P1
ModellingSolution_P2
ModellingSolution_Pn
Plugin can use either a running instance of the model (Model plug-ins) or data only (Tool plug-ins)
The DataLayer allows linking to different persistence means (e.g. DB Oracle, PostgreSQL, XML, File System)
BioMA GUI-Spatial can run all modelling solutions; BioMA GUI-Point can run only point modelling solutions


BioMA
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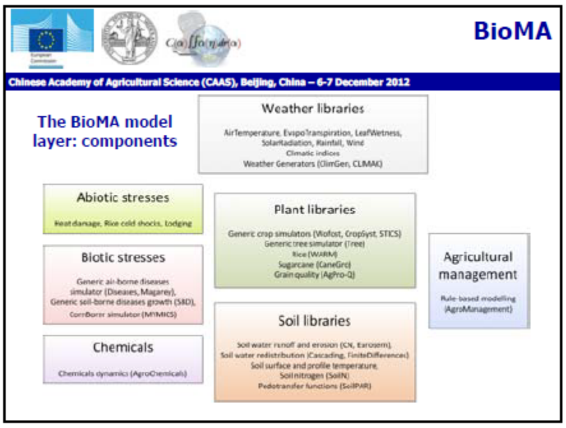
JRC MARS Soil Grid DB
JRC Land use DB
JRC MARS AgroMan DB
JRC MARS Weather Grid DB Historical series
CLIMA weather generator
JRC MARS Weather Grid DB IPCC scenarios
JRC MARS Weather Grid DB hourly values
BioMA Framework
Pests Models
Diseases Models
Plant Models
Soil Models
AgroManagement Models
Modelling solutions
WARM
APES
CropSyst-WL
Wofost-WL
???
LUISA (Sensitivity)
Optimizer (Calibration)
IMMA (Evaluation)
Simulation outputs
Map data
Map images
Sensitivity analysis
Model evaluation
Joint Research Centre


BioMA
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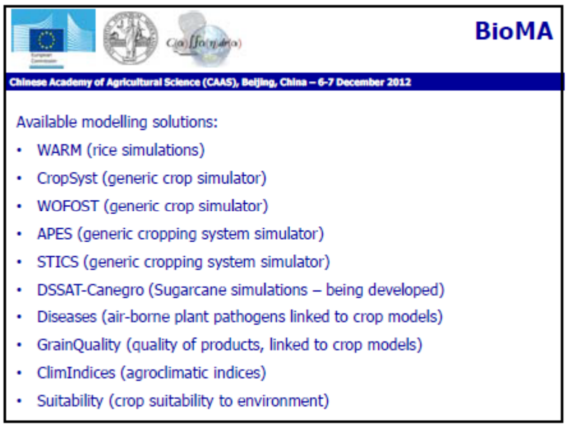
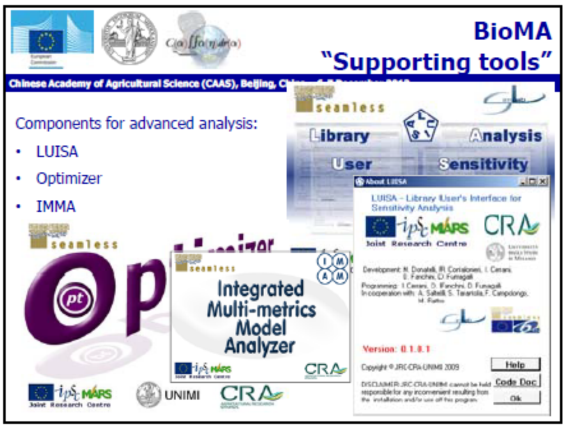
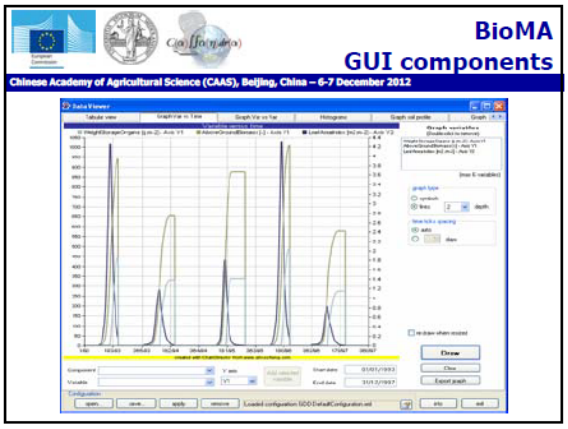
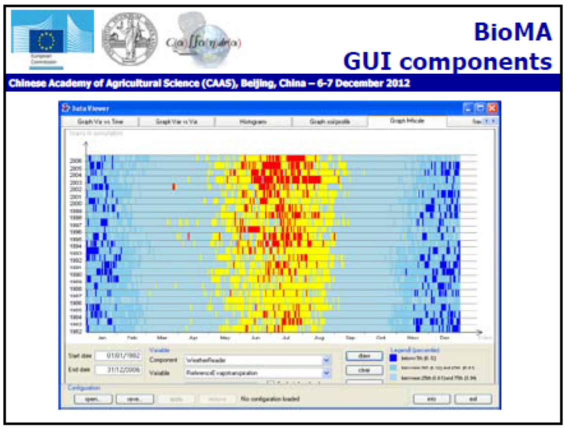
The BioMA model layer: components
Weather libraries
AirTemperature, EvapoTranspiration, LeafWetness, SolarRadiation, Rainfall, Wind
Climatic indices
Weather Generators (ClimGen, CLIMA)
Abiotic stresses
Heat damage, Rice cold shocks, Lodging
Biotic stresses
Generic air-borne diseases simulator (Diseases, Magarey), Generic soil-borne diseases growth (SBD), CornBorer simulator (MYMICS)
Chemicals
Chemicals dynamics (AgroChemicals)
Plant libraries
Generic crop simulators (Wofost, CropSyst, STICS)
Generic tree simulator (Tree)
Rice (WARM)
Sugarcane (CaneGro)
Grain quality (AgroQ)
Soil libraries
Soil water runoff and erosion (CN, Eurosem), Soil water redistribution (Cascading, FiniteDifference)
Soil surface and profile temperature
Soil nitrogen (SoilN)
Pedotransfer functions (SoilPAR)
Agricultural management
Rule-based modelling (AgroManagement)


BioMA
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Available modelling solutions:
WARM (rice simulations)
CropSyst (generic crop simulator)
WOFOST (generic crop simulator)
APES (generic cropping system simulator)
STICS (generic cropping system simulator)
DSSAT-Canegro (Sugarcane simulations – being developed)
Diseases (air-borne plant pathogens linked to crop models)
GrainQuality (quality of products, linked to crop models)
ClimIndices (agroclimatic indices)
Suitability (crop suitability to environment)


BioMA
"Supporting tools"
Chinese Academy of Agricultural Science (CAAS), Beijing, China
Components for advanced analysis:
LUISA
Optimizer
IMMA
seamless
Library
Analysis
User
Sensitivity
LUISA – Library User's Interface for Sensitivity Analysis
Joint Research Centre
Integrated Multi-metrics Model Analyzer
Version: 0.1.8.1
Help
Code Doc
Ok
UNIMI
CRA


BioMA
GUI components
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Data Viewer


BioMA
GUI components
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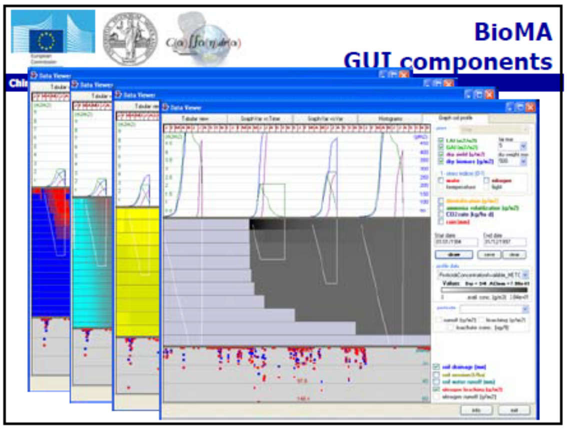
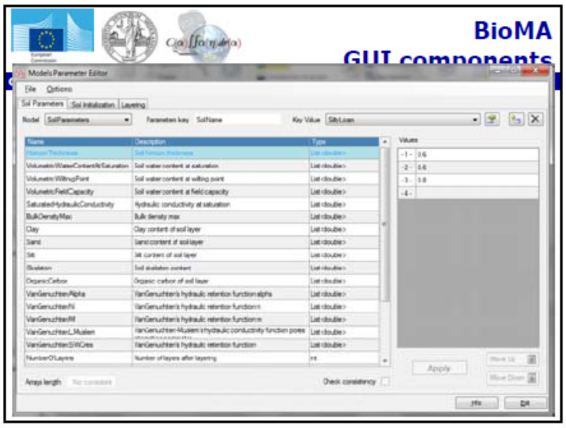
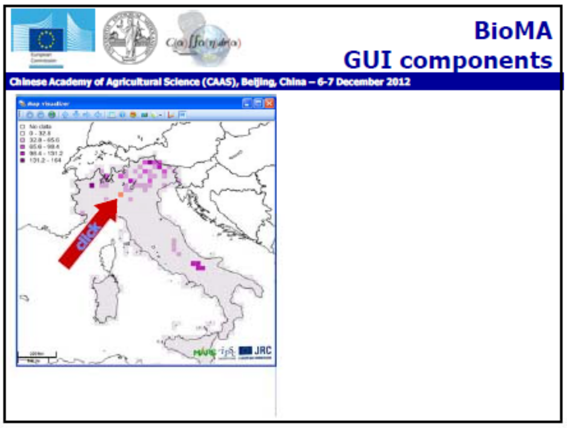
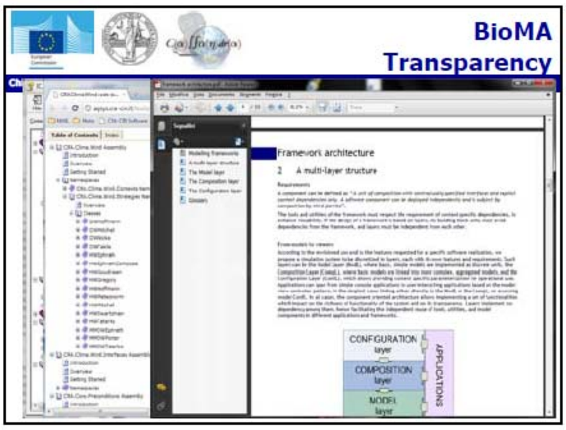

BioMA


BioMA


BioMA
GUI components
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012


BioMA
Transparency


BioMA

Outline

Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012

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Conclusions

Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012

Applications developed on the base of the BioMA framework are currently capable to address many aspects related to the biophysics of agricultural production.

BioMA neither is a model nor proposes a model. Instead, it is an open platform to make available in operational software the results of researches on biophysical modelling in agriculture.

Adopting a component oriented development, extended both to models and tools, fosters re-usability without forcing third parties toward investing exclusively on a specific framework/model they do not own.

We make available BioMA as a platform, but also, and of no lesser importance, as a loose collection of model objects and software tools re-usable in other platforms.

Conclusions

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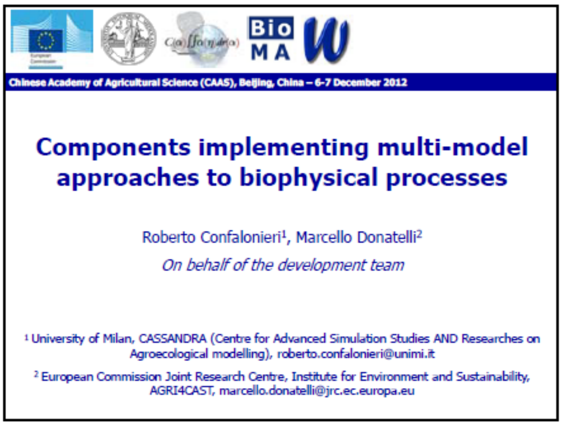
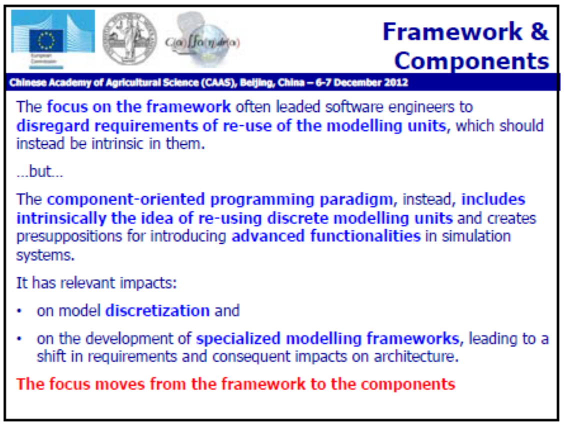
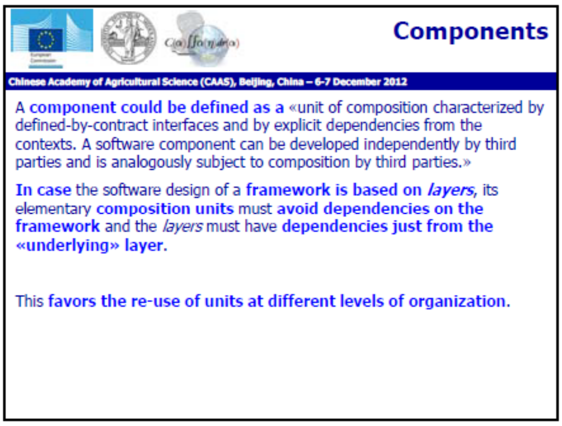
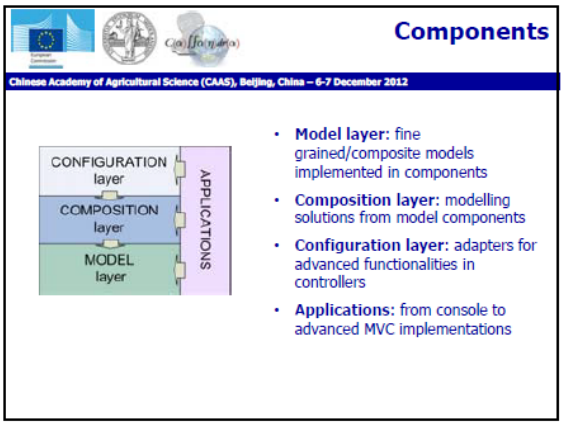
5. Appendix B

Components implementing multi-model approaches to biophysical processes


Bio
MA
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Components implementing multi-model approaches to biophysical processes
Roberto Confalonieri[1], Marcello Donatelli[2]
On behalf of the development team
[1] University of Milan, CASSANDRA (Centre for Advanced Simulation Studies AND Researches on Agroecological modelling), roberto.confalonieri@unimi.it
[2] European Commission Joint Research Centre, Institute for Environment and Sustainability, AGRI4CAST, marcello.donatelli@jrc.ec.europa.eu


Framework & Components
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
The focus on the framework often leaded software engineers to disregard requirements of re-use of the modelling units, which should instead be intrinsic in them.
...but...
The component-oriented programming paradigm, instead, includes intrinsically the idea of re-using discrete modelling units and creates presuppositions for introducing advanced functionalities in simulation systems.
It has relevant impacts:
• on model discretization and
• on the development of specialized modelling frameworks, leading to a shift in requirements and consequent impacts on architecture.
The focus moves from the framework to the components


Components
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
A component could be defined as a «unit of composition characterized by defined-by-contract interfaces and by explicit dependencies from the contexts. A software component can be developed independently by third parties and is analogously subject to composition by third parties.»
In case the software design of a framework is based on layers, its elementary composition units must avoid dependencies on the framework and the layers must have dependencies just from the «underlying» layer.
This favors the re-use of units at different levels of organization.


Components
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
CONFIGURATION layer
COMPOSITION layer
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• Model layer: fine grained/composite models implemented in components
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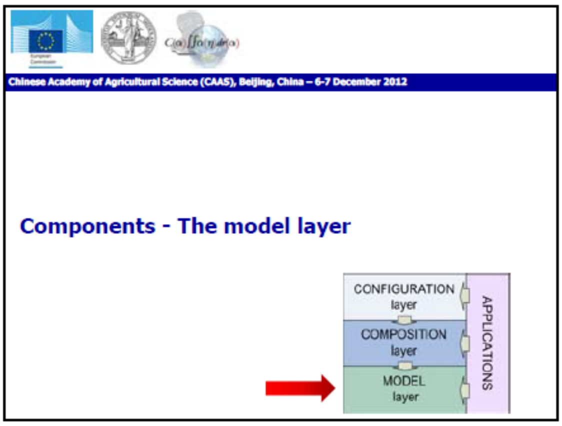
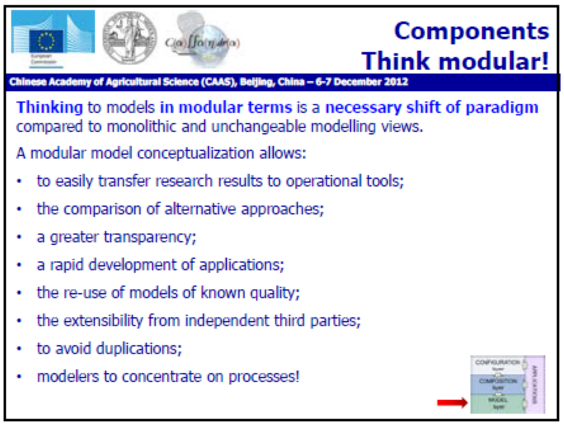
• Applications: from console to advanced MVC implementations


Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Components - The model layer
CONFIGURATION layer
COMPOSITION layer
MODEL layer
APPLICATIONS


Components
Think modular!
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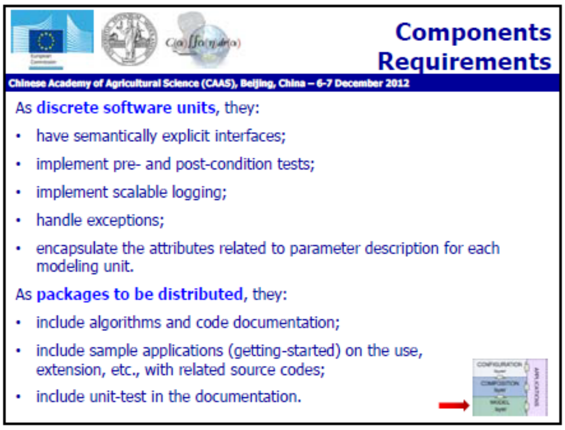
Thinking to models in modular terms is a necessary shift of paradigm compared to monolithic and unchangeable modelling views.
A modular model conceptualization allows:
• to easily transfer research results to operational tools;
• the comparison of alternative approaches;
• a greater transparency;
• a rapid development of applications;
• the re-use of models of known quality;
• the extensibility from independent third parties;
• to avoid duplications;
• modelers to concentrate on processes!


Components
Requirements
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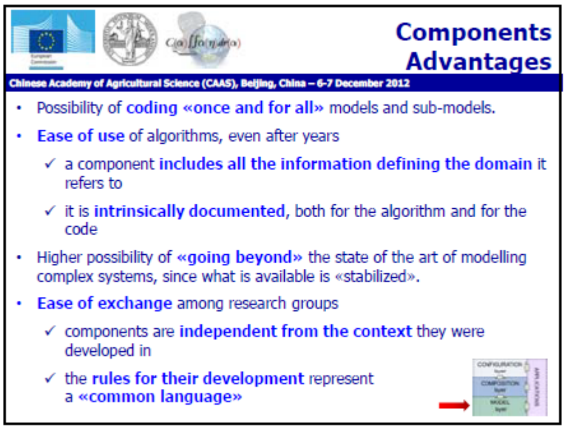
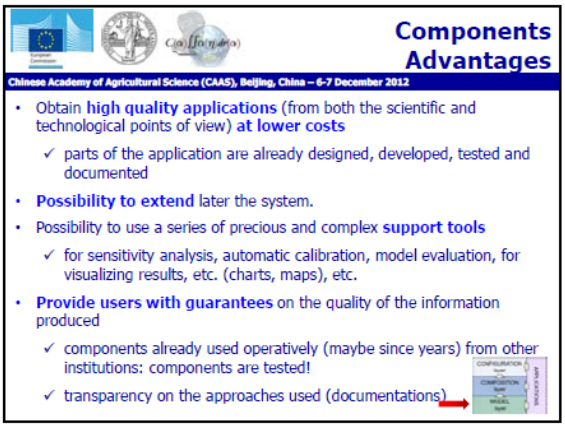
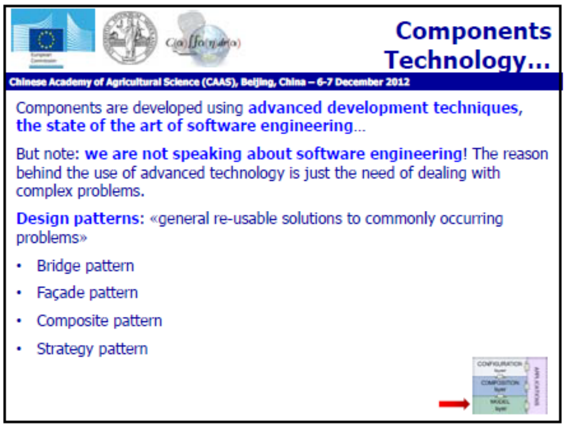
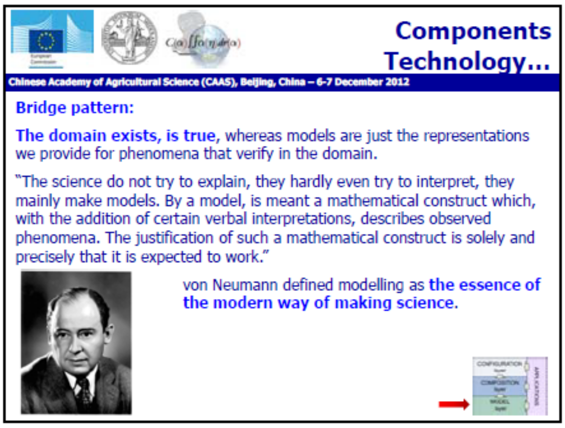
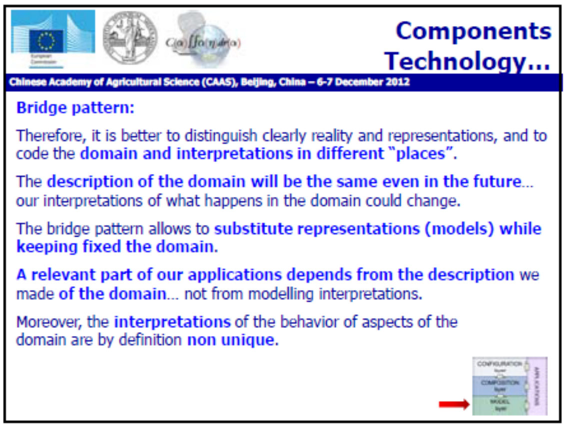
As discrete software units, they:
• have semantically explicit interfaces;
• implement pre- and post-condition tests;
• implement scalable logging;
• handle exceptions;
• encapsulate the attributes related to parameter description for each modeling unit.
As packages to be distributed, they:
• include algorithms and code documentation;
• include sample applications (getting-started) on the use, extension, etc., with related source codes;
• include unit-test in the documentation.


Components
Advantages
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
• Possibility of coding «once and for all» models and sub-models.
• Ease of use of algorithms, even after years
✓ a component includes all the information defining the domain it refers to
✓ it is intrinsically documented, both for the algorithm and for the code
• Higher possibility of «going beyond» the state of the art of modelling complex systems, since what is available is «stabilized».
• Ease of exchange among research groups
✓ components are independent from the context they were developed in
✓ the rules for their development represent a «common language»


Components
Advantages
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
• Obtain high quality applications (from both the scientific and technological points of view) at lower costs
✓ parts of the application are already designed, developed, tested and documented
• Possibility to extend later the system.
• Possibility to use a series of precious and complex support tools
✓ for sensitivity analysis, automatic calibration, model evaluation, for visualizing results, etc. (charts, maps), etc.
• Provide users with guarantees on the quality of the information produced
✓ components already used operatively (maybe since years) from other institutions: components are tested!
✓ transparency on the approaches used (documentations)


Components
Technology…
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Components are developed using advanced development techniques, the state of the art of software engineering…
But note: we are not speaking about software engineering! The reason behind the use of advanced technology is just the need of dealing with complex problems.
Design patterns: «general re-usable solutions to commonly occurring problems»
• Bridge pattern
• Façade pattern
• Composite pattern
• Strategy pattern


Components
Technology…
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Bridge pattern:
The domain exists, is true, whereas models are just the representations we provide for phenomena that verify in the domain.
"The science do not try to explain, they hardly even try to interpret, they mainly make models. By a model, is meant a mathematical construct which, with the addition of certain verbal interpretations, describes observed phenomena. The justification of such a mathematical construct is solely and precisely that it is expected to work."
von Neumann defined modelling as the essence of the modern way of making science.


Components
Technology…
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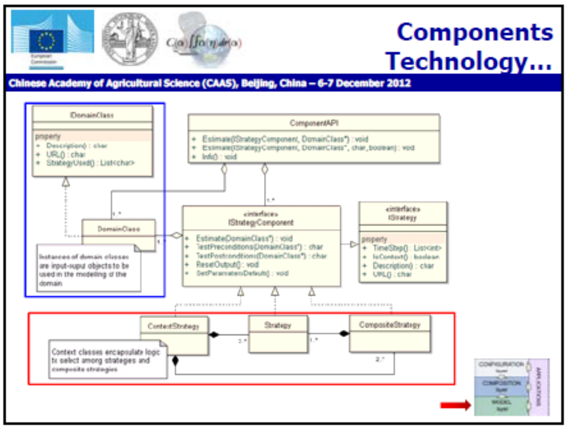
Bridge pattern:
Therefore, it is better to distinguish clearly reality and representations, and to code the domain and interpretations in different "places".
The description of the domain will be the same even in the future… our interpretations of what happens in the domain could change.
The bridge pattern allows to substitute representations (models) while keeping fixed the domain.
A relevant part of our applications depends from the description we made of the domain… not from modelling interpretations.
Moreover, the interpretations of the behavior of aspects of the domain are by definition non unique.


Components
Technology…
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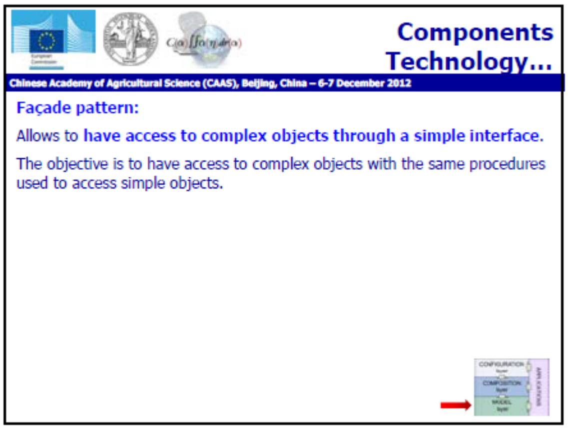
Components
Technology…
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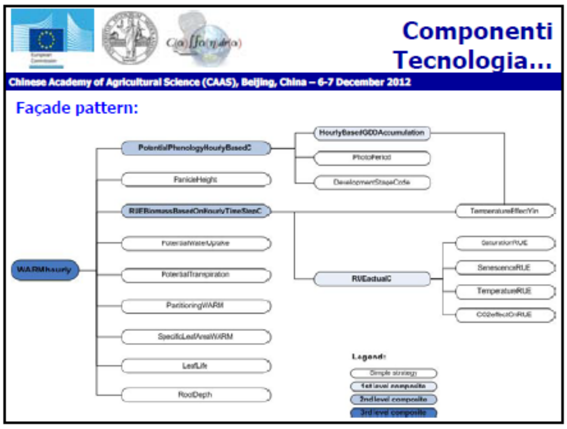
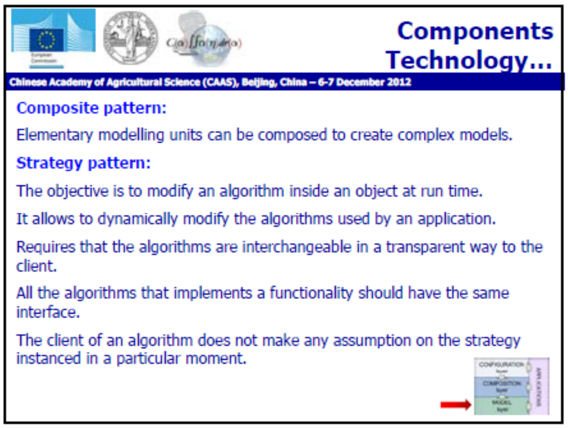
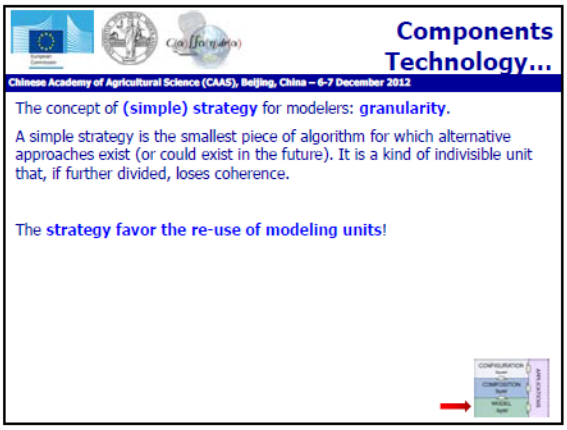
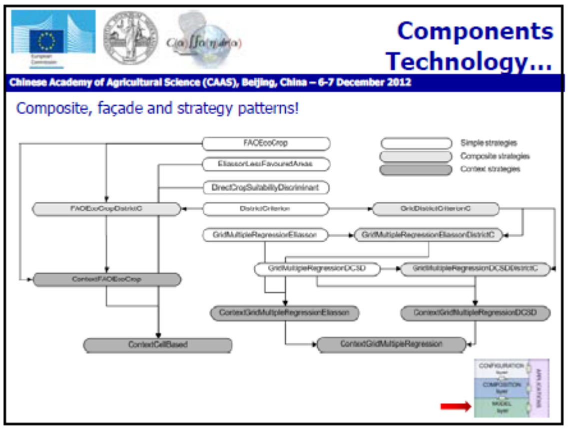
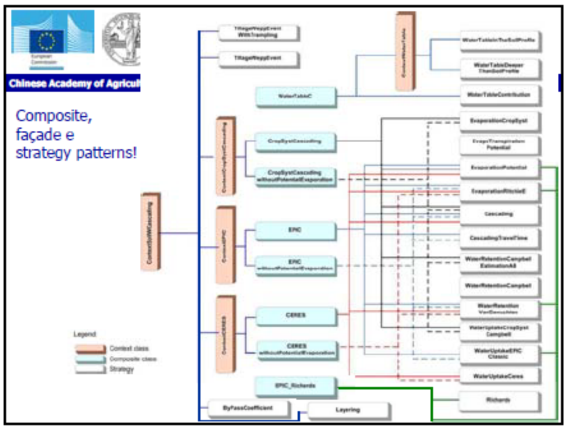
Façade pattern:
Allows to have access to complex objects through a simple interface.
The objective is to have access to complex objects with the same procedures used to access simple objects.

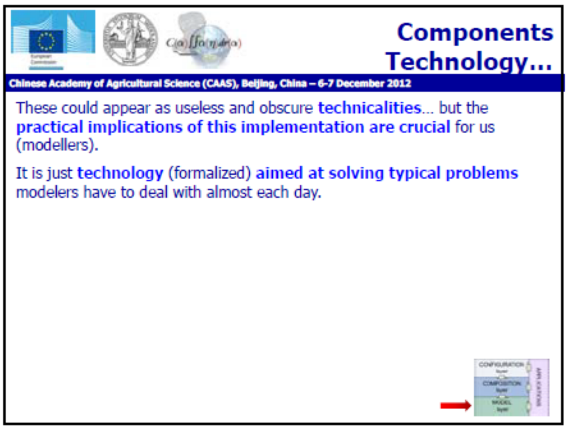

Componenti
Tecnologia…
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Façade pattern:

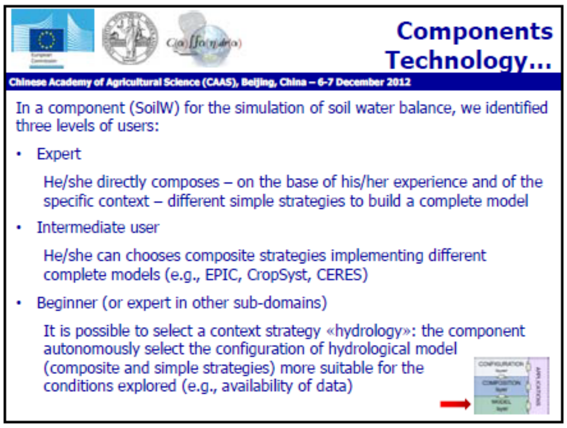

Components
Technology…
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Composite pattern:
Elementary modelling units can be composed to create complex models.
Strategy pattern:
The objective is to modify an algorithm inside an object at run time.
It allows to dynamically modify the algorithms used by an application.
Requires that the algorithms are interchangeable in a transparent way to the client.
All the algorithms that implements a functionality should have the same interface.
The client of an algorithm does not make any assumption on the strategy instanced in a particular moment.

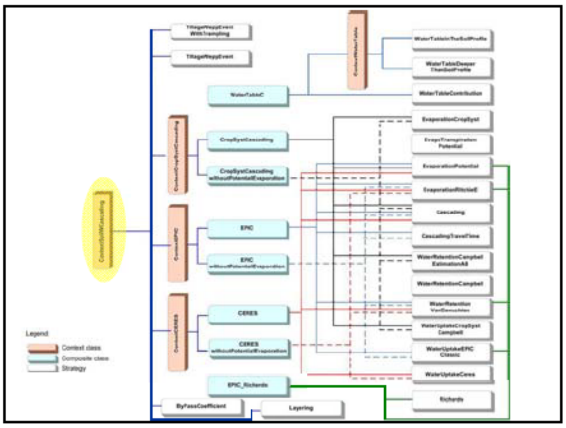

Components
Technology…
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
The concept of (simple) strategy for modelers: granularity.
A simple strategy is the smallest piece of algorithm for which alternative approaches exist (or could exist in the future). It is a kind of indivisible unit that, if further divided, loses coherence.
The strategy favor the re-use of modeling units!

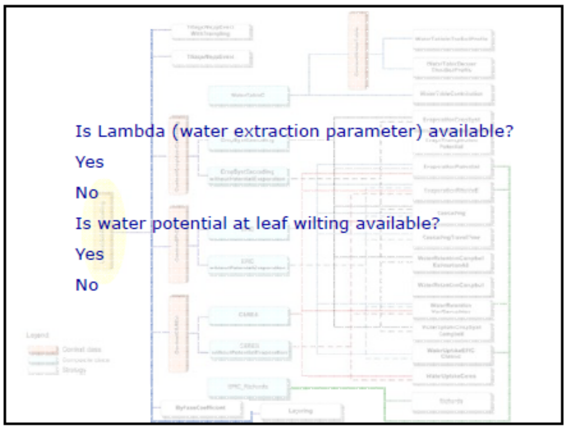

Components
Technology…
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Composite, façade and strategy patterns!

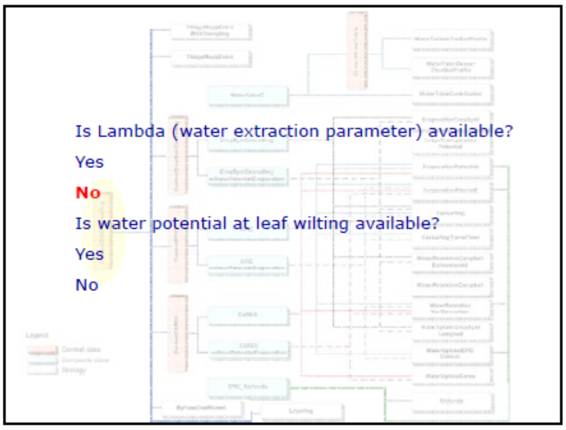

Chinese Academy of Agricul
Composite,
façade e
strategy patterns!
Legend
Context class
Composite class
Strategy

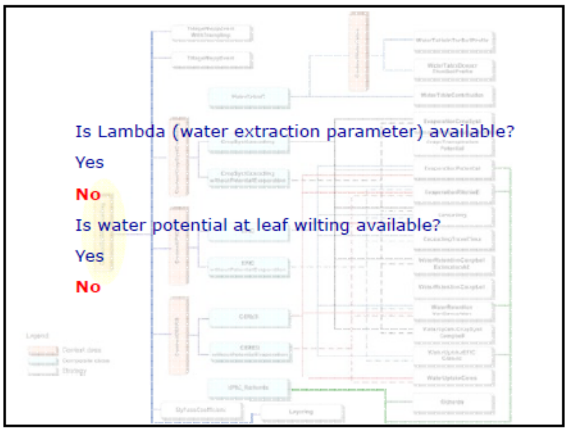

Components
Technology…
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
These could appear as useless and obscure technicalities… but the practical implications of this implementation are crucial for us (modellers).
It is just technology (formalized) aimed at solving typical problems modelers have to deal with almost each day.

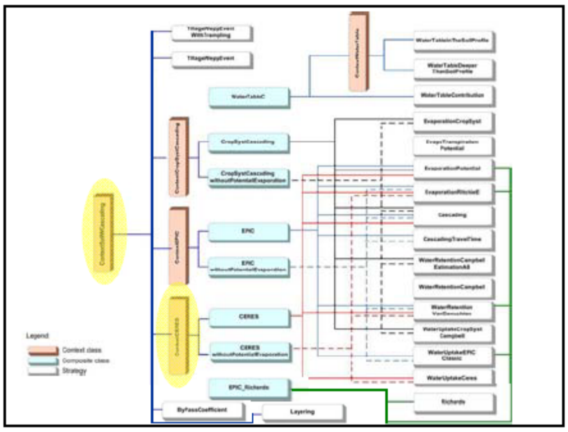

Components
Technology…
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
In a component (SoilW) for the simulation of soil water balance, we identified three levels of users:
• Expert
He/she directly composes – on the base of his/her experience and of the specific context – different simple strategies to build a complete model
• Intermediate user
He/she can chooses composite strategies implementing different complete models (e.g., EPIC, CropSyst, CERES)
• Beginner (or expert in other sub-domains)
It is possible to select a context strategy «hydrology»: the component autonomously select the configuration of hydrological model (composite and simple strategies) more suitable for the conditions explored (e.g., availability of data)

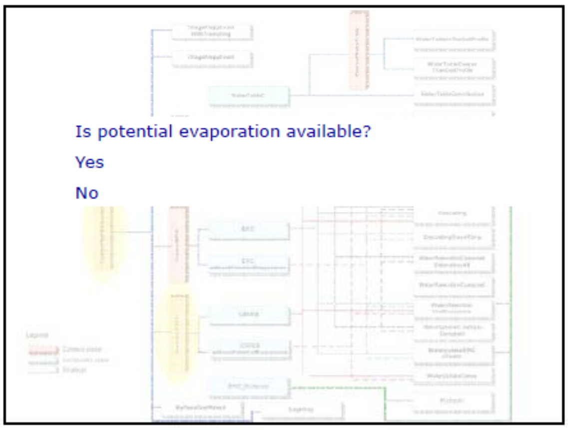

Legend
Context class
Composite class
Strategy

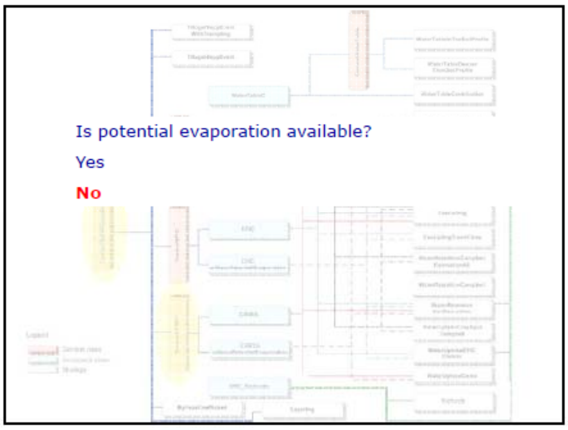

Is Lambda (water extraction parameter) available?
Yes
No
Is water potential at leaf wilting available?
Yes
No

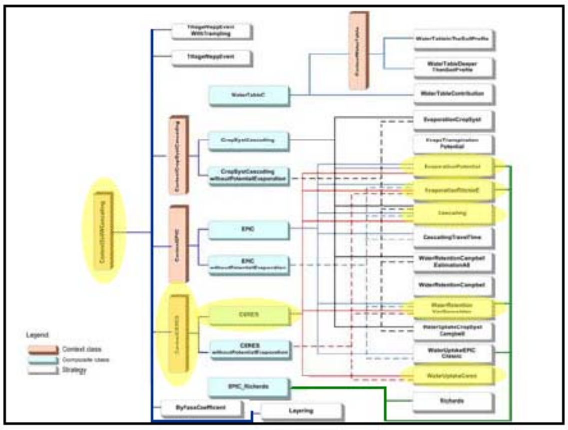

Is Lambda (water extraction parameter) available?
Yes
No
Is water potential at leaf wilting available?
Yes
No

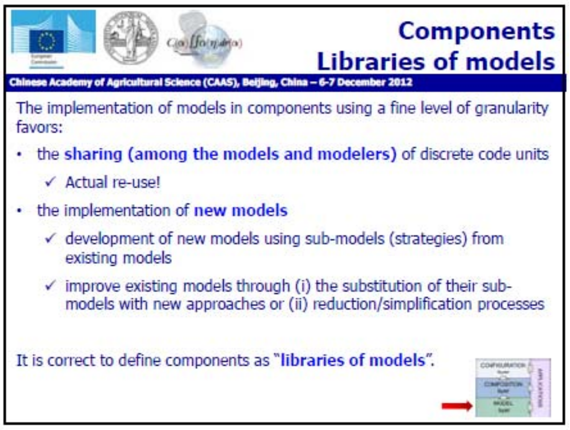

Is Lambda (water extraction parameter) available?
Yes
No
Is water potential at leaf wilting available?
Yes
No

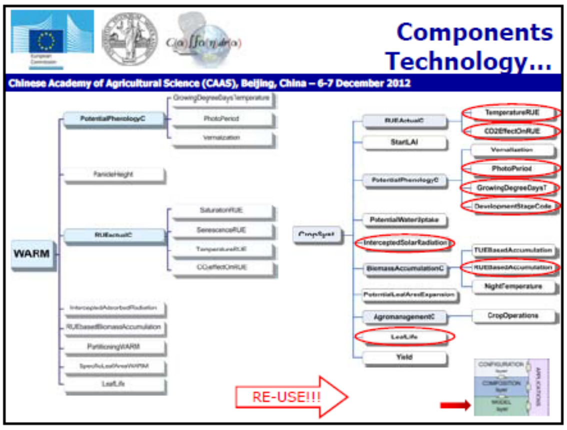


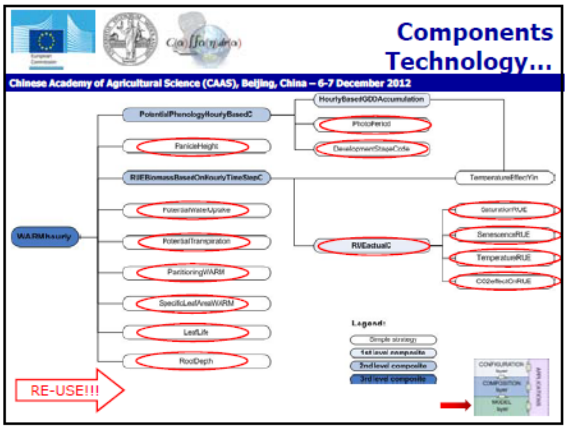

Is potential evaporation available?
Yes
No


Is potential evaporation available?
Yes
No




Components
Libraries of models
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
The implementation of models in components using a fine level of granularity favors:
• the sharing (among the models and modelers) of discrete code units
✓ Actual re-use!
• the implementation of new models
✓ development of new models using sub-models (strategies) from existing models
✓ improve existing models through (i) the substitution of their sub-models with new approaches or (ii) reduction/simplification processes
It is correct to define components as "libraries of models".





Components – Libraries of models

Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012

Why is it so important to have libraries of models?

Several models are available in the literature, characterized by common parts and by parts that make them different.

The modelers community is now considering proved that it is **not reasonable trying to identify «the best model»**, having demonstrated that different models can be more suitable:

- under different conditions of application
- for the specific aims of a modelling study

Multi-approach libraries make easier

- **to identify**, for a specific study, **the most suitable model** and
- **to easily use it** since it is integrated – like the others – in the same simulation environment (same access to a database, same tools for visualizing results, etc.).

Components – Libraries of models

Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012

Multi-approach libraries also favor **parallel model executions** (multi-model simulations).

Especially when there is the need of performing simulations exploring different conditions (in space or time), it is possible that a model implementing a certain approach to one process is more suitable under specific regions or time frames (seasons, climate scenarios).

In this case, the statistical post-processing of simulated data could lead to select variables simulated by different models under different conditions (**EU-FP7 E-AGRI**).

Components – Libraries of models

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Process	WOFOST	CropSyst	WARM
Development	Thermal time accumulation, possibly accounting for photoperiod and vernalization (only for CropSyst)		
Daily biomass accumulation	Gross photosynthesis	Net photosynthesis min(TUE_{VPD},RUE)	Net photosynthesis (RUE)
Factors limiting biomass accumulation	Air Temperature	Air temperature (explicitly only on RUE)	Air temperature, enzymatic chains saturation, senescence
Dynamic biomass partitioning	Growth respiration, partitioning factors, efficiency of conversion	Not considered	Function of development stage
Leaf area development	Development dependant SLA (air temp. for LAI < 1); death for senescence and self-shading	AGB and constant SLA (empiric); death for senescence	Development dependant SLA; death for senescence
Canopy architecture	Three layers	Monolayer	Monolayer

Components – MCE

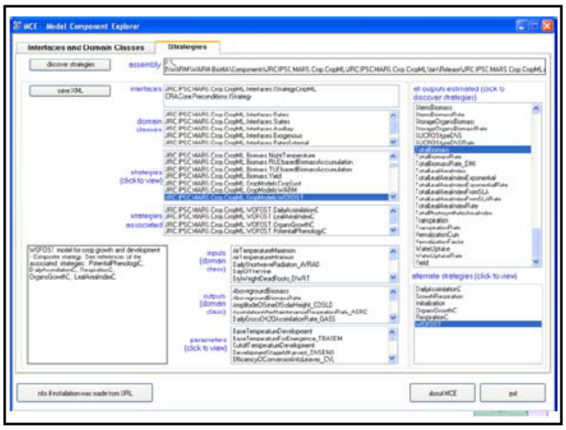
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012

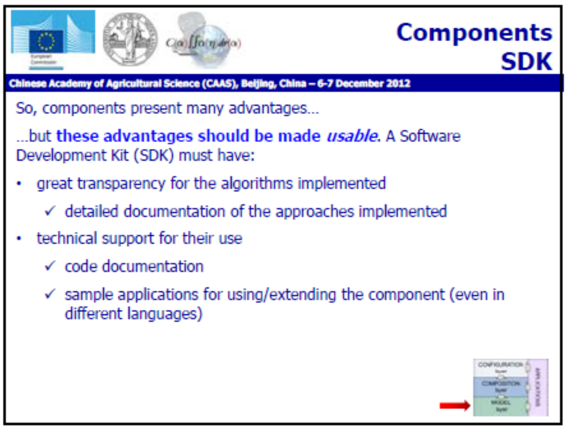
Components can be explored!

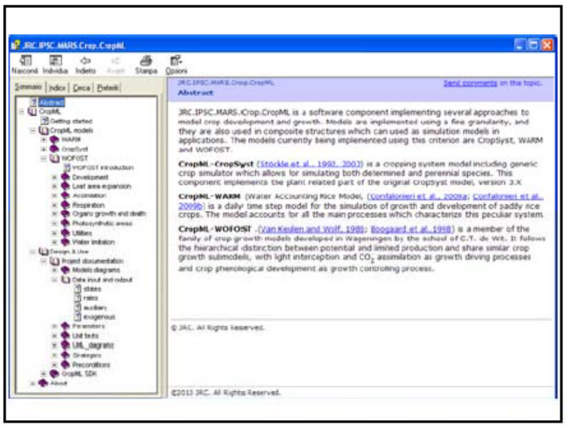
MCE (Model Component Explorer) allows to have access to data-types description (inputs, outputs, model), and to discover interfaces.

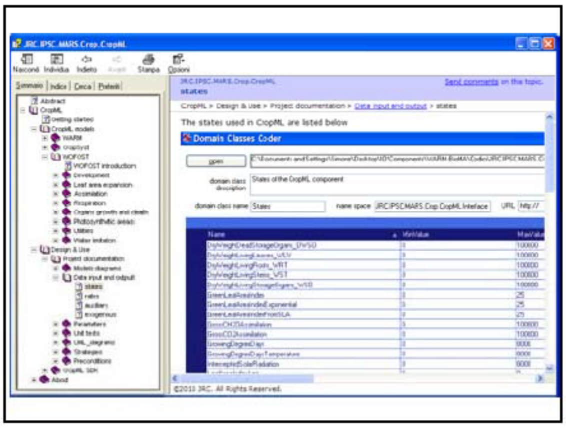
It shows the real implementation of some of the requirements of the components just discussed.

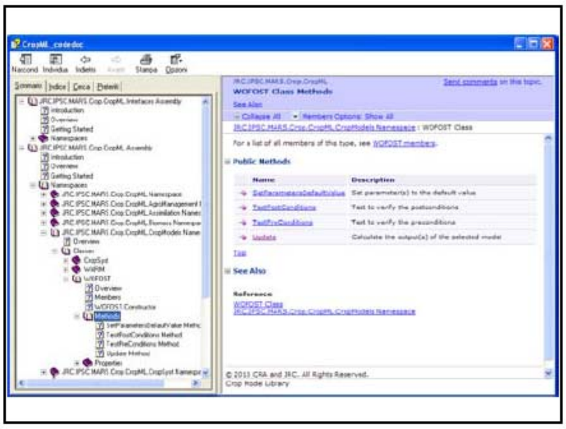
All the components developed according to the architecture presented can be inspected using this application.

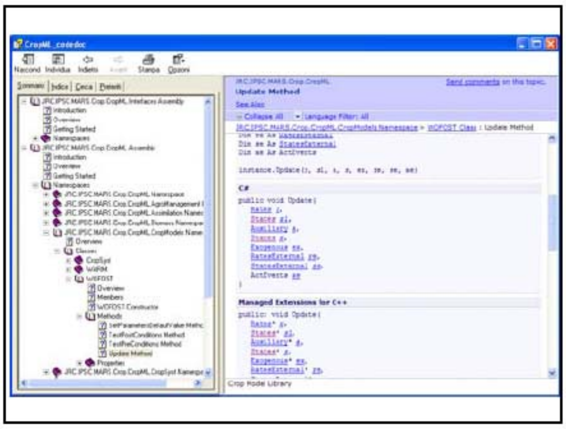


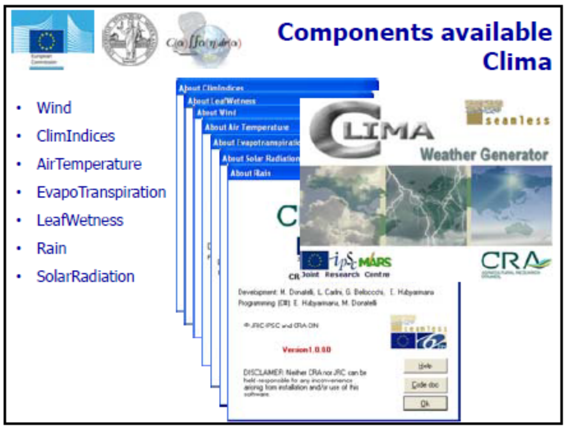

Components SDK
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
So, components present many advantages…
…but these advantages should be made *usable*. A Software Development Kit (SDK) must have:
great transparency for the algorithms implemented
detailed documentation of the approaches implemented
technical support for their use
code documentation
sample applications for using/extending the component (even in different languages)

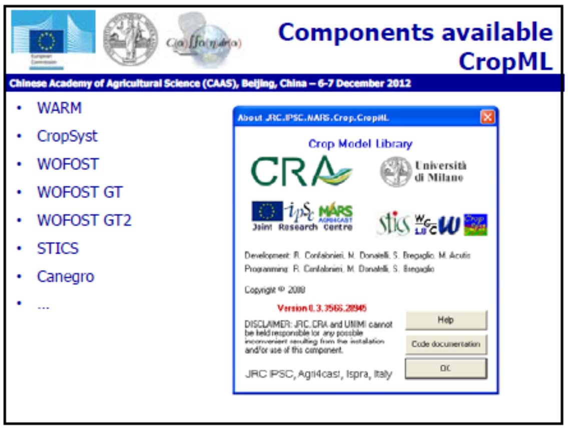




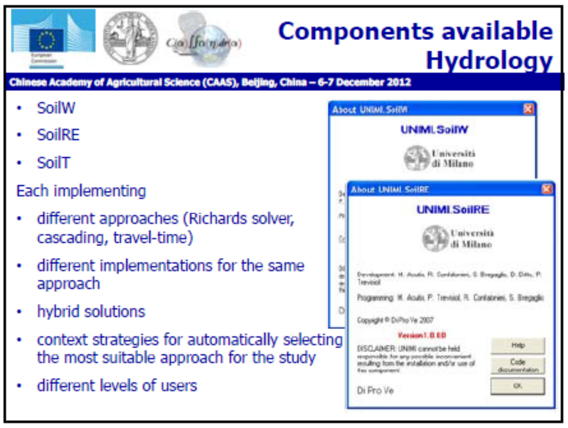


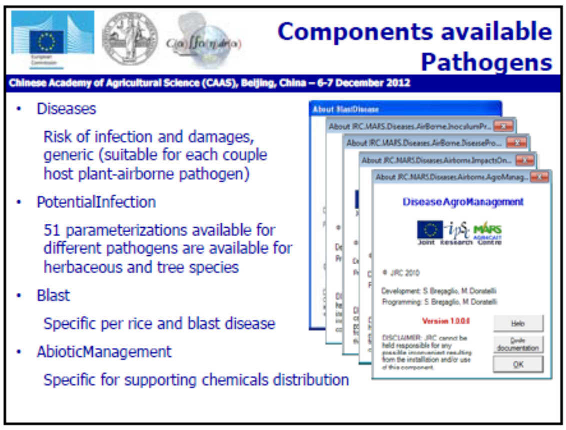


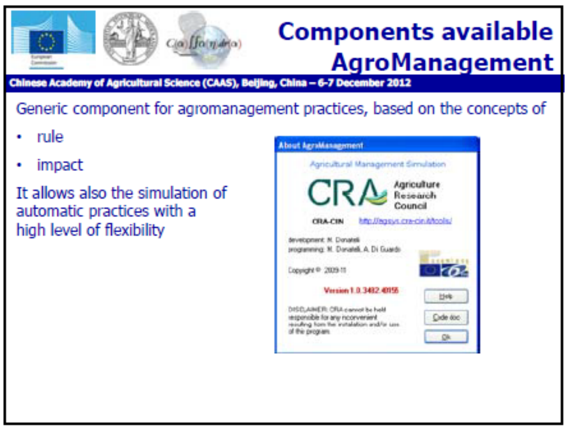

Components available
Clima
Wind
ClimIndices
AirTemperature
EvapoTranspiration
LeafWetness
Rain
SolarRadiation
CLIMA
Weather Generator
seamless

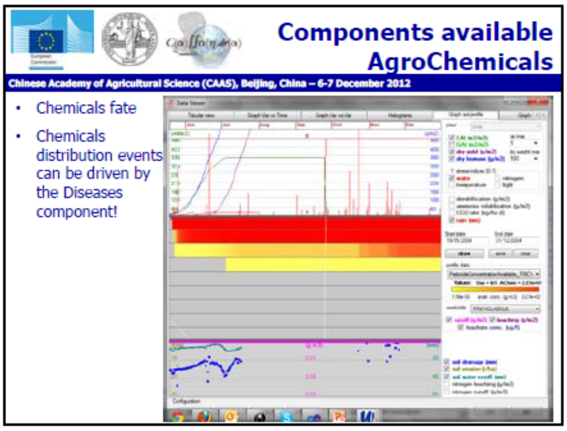

Components available
CropML
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
WARM
CropSyst
WOFOST
WOFOST GT
WOFOST GT2
STICS
Canegro
...
Crop Model Library
JRC IPSC, Agri4cast, Ispra, Italy

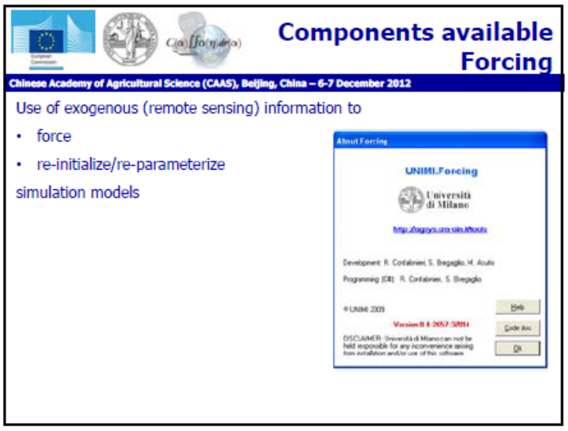

Components available
AbioticDamage
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
frost
temperature shocks
salinity
lodging
ozone
AbioticDamage

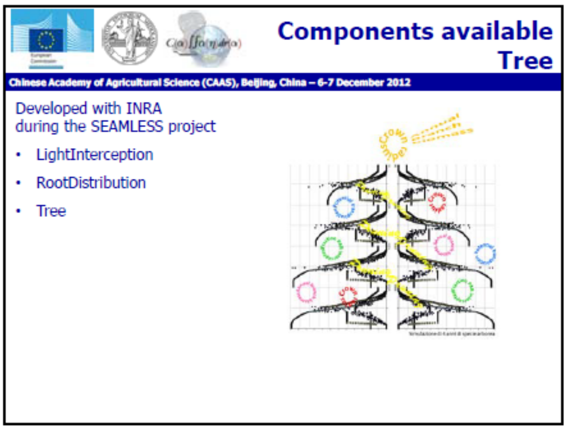

Components available
Hydrology
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
SoilW
SoilRE
SoilT
Each implementing
different approaches (Richards solver, cascading, travel-time)
different implementations for the same approach
hybrid solutions
context strategies for automatically selecting the most suitable approach for the study
different levels of users
UNIMI.SoilW
UNIMI.SoilRE

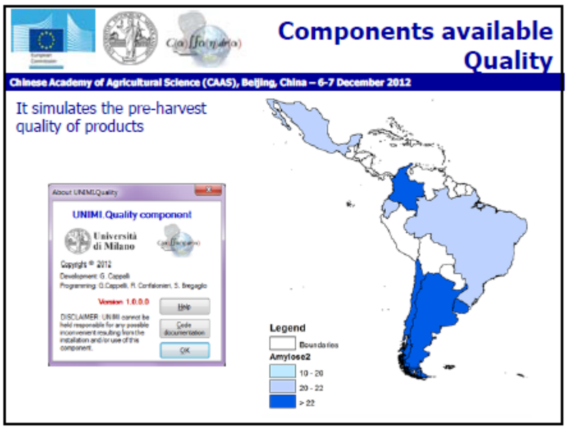

Components available
Pathogens
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Diseases
Risk of infection and damages, generic (suitable for each couple host plant-airborne pathogen)
PotentialInfection
51 parameterizations available for different pathogens are available for herbaceous and tree species
Blast
Specific per rice and blast disease
AbioticManagement
Specific for supporting chemicals distribution
DiseaseAgroManagement

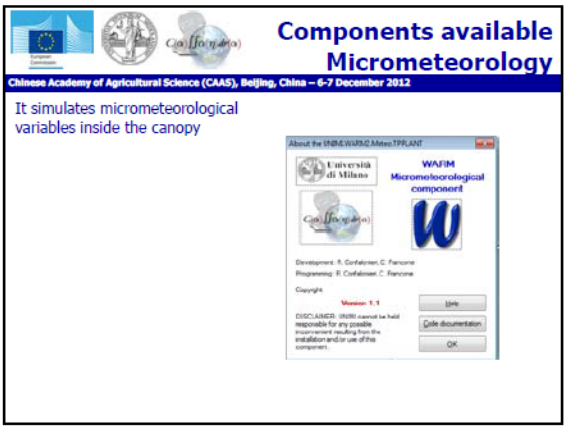

Components available
AgroManagement
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Generic component for agromanagement practices, based on the concepts of
rule
impact
It allows also the simulation of automatic practices with a high level of flexibility

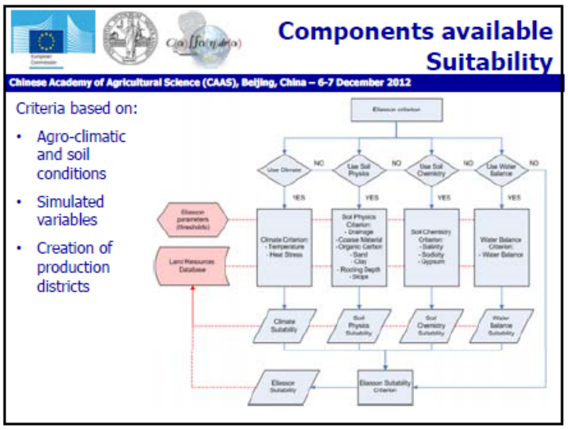

Components available
AgroChemicals
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Chemicals fate
Chemicals distribution events can be driven by the Diseases component!

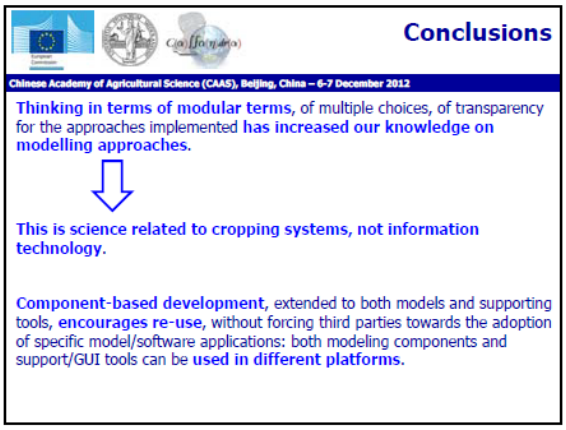

Components available
Forcing
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Use of exogenous (remote sensing) information to
force
re-initialize/re-parameterize
simulation models
UNIMI.Forcing


Components available
Tree
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Developed with INRA
during the SEAMLESS project
LightInterception
RootDistribution
Tree


Components available
Quality
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
It simulates the pre-harvest
quality of products
UNIMI.Quality component
Legend
Boundaries
Amylose2
10 - 20
20 - 22
> 22


Components available
Micrometeorology
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
It simulates micrometeorological
variables inside the canopy
WARM
Micrometeorological component


Components available
Suitability
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Criteria based on:
Agro-climatic and soil conditions
Simulated variables
Creation of production districts


Conclusions
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Thinking in terms of modular terms, of multiple choices, of transparency for the approaches implemented has increased our knowledge on modelling approaches.
This is science related to cropping systems, not information technology.
Component-based development, extended to both models and supporting tools, encourages re-use, without forcing third parties towards the adoption of specific model/software applications: both modeling components and support/GUI tools can be used in different platforms.


Conclusions
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Contents lists available at SciVerse ScienceDirect
Computers and Electronics in Agriculture
journal homepage: www.elsevier.com/locate/compag
ELSEVIER
Application note
A multi-approach software library for estimating crop suitability to environment
R. Confalonieri, C. Francone, G. Cappelli, T. Stella, N. Frasso, M. Carpani, S. Bregaglio, M. Acutis, F.N. Tubiello, E. Fernandes


Many thanks for your kind attention

6. Appendix C

Questionnaire: Workshop participants' feedback

EUROPEAN COMMISSION
JOINT RESEARCH CENTRE
Institute for Environment and Sustainability (Ispra)

University of Milan

BioMA workshops
Participant's feedback

Dear participant, please take a few minutes to fill out this feedback form. It will help us to assess how well this event met your expectations and will contribute to the improvement of future initiatives. Many thanks for your contribution.

Event:	
Date(s):	
Location:	
Organiser:	
Participant's name (optional):	

Event's preparation	**Below expectations**	**Met expectations**	**Above expectations**	**N / A**
Programme				
Objectives				
Selection of speakers				
Event's delivery	**Below expectations**	**Met expectations**	**Above expectations**	**N / A**
Contents, quality of presentations				
Discussion time / interaction between participants				
Workshops / sub-sessions				
Balance between sessions				
Speakers performance				

Supporting material				
Provision of additional resources (useful links, downloads, contacts)				
Organisation and Logistics	**Below expectations**	**Met expectations**	**Above expectations**	**N / A**
Organisation, location, communication with the participants, side events				
Content	**Below expectations**	**Met expectations**	**Above expectations**	**N / A**
Capacity of the training to meet your learning objectives and its relevance for your work				
Quality and accuracy of contents				
Methodology	**Below expectations**	**Met expectations**	**Above expectations**	**N / A**
Length of the course and balance between theory and practice				
Possibility of interaction with trainer and other participants				
Learning Resources (Manuals, Presentation Material, Hand-outs, etc)	**Below expectations**	**Met expectations**	**Above expectations**	**N / A**
Usefulness and usability of course material/presentations				
Provision of additional resources (useful links, downloads, contacts)				
Trainer / Facilitator	**Below expectations**	**Met expectations**	**Above expectations**	**N / A**
Trainer's communication and interaction				
Trainer's knowledge of the topic				
General Comments	**Below expectations**	**Met expectations**	**Above expectations**	**N / A**
Overall evaluation of the event				
Any additional comment (especially for explaining the reasons for “below expectations")				

7. Appendix D

Minutes of the 2nd BioMA workshop held at the Institut National de la Recherche Agronomique from 19th to 21th March 2013

Participants: see the list of the workshop participants

Riad Balaghi (introduction about state of art of INRA activities): in the next weeks the CGMS visualizer and the seasonal forecasting will be available on the web: www.cgms-maroc.ma

Roberto Confalonieri (presentation of three study cases on model-based yield forecasting) Is it possible to estimate sowing date in MAROCCO with NDVI?

Riad Balaghi: yes, but we do not have observations to check the reliability of the date estimation.

Mohammed Karrou: despite the sowing event can be on the same day, the inter-variety genetic variability is decidedly high.

Saadia Lhaloui: yes, different varieties have different degree of tolerance (not only about sterility). Moreover, be careful about the difference between the terms drought and dry (e.g., case without rain but high relative humidity). The sowing in Morocco occurs after the first substantial rainfall of the season.

Mohammed Karrou: I am surprised by the case studies you presented since in Morocco the yield forecast are never close to statistics. I would like to better understand how the statistical tool works.

Saadia Lhaloui: there is not that big impact of Black rust in Morocco.

Tarik El Hairech: I would like to understand the importance of the DVS as a simulated index for the forecasting since in Wofost its value is fixed until maturity.

Mohammed Karrou: how can the model distinguish between physiological maturity and harvest?

Hassan Ouabbou: can the impact of insects be simulated by the models? In Morocco the Hessian fly is an important source of crop damage. As a consequence, a mitigation strategy is directly linked to the sowing date.

Saadia Lhaloui: for national scale forecasting, the difference among soil physical and chemical characteristics are not so relevant as a regional scale.

Riad Balaghi: rainfall is explaining the most part of variability of national yield, thus soil properties are of secondary importance at this scale.

Simone Bregaglio (presentation about the disease component)

Saadia Lhaloui: does the model take into account spore dynamic? The direction of wind is very important. We have a database of disease severity and senescent tissues observations, but not about spore.

Tarik El Hairech: in the meteorological database we use for yield forecasting (9x9 km^2) there is wind speed, but it is more complex to interpolate wind direction on the grid.

Simone Bregaglio (presentation about Wofost calibration in Morocco)

Hassan Ouabbou and Saadia Lhaloui: we recorded the emergency day of our field trials, we can support you with this data. The SEA site is very dry and we had problems with irrigation. That is the reason for LAI decrement. Nevertheless, these varieties are resistant and the production was decidedly high. We can support you with meteorological data of the KHZ site. The biomass in KHZ sharply decrease after the flowering phase because of tissue senescence because of disease. Otherwise, we had some problem in the drying process of fresh biomass. Arrihane is the more resistant variety against disease and Hessian Fly.

Riad Balaghi: we can set different calibrations for the soft varieties whereas only one parameter set is sufficient to describe durum variety behaviour. About soil initialization in the model, in the 2012 season the soil was dry until the first rainfall. In summer soil water content is around the wilting point value.

Hassan Ouabbou: in 2013 we will monitor the aboveground biomass after the flowering phase. The variety behaviour is independent from the place the crop is cultivated.

Saadia Lhaloui: we could retrieve a kind of variety database on the Moroccan country by asking the purchasing statistics of seeds about the last 5 years. Or we could use the remote sensing technology. Be aware of use of the length of phenological phases as a proxy of different varieties.

8. Appendix E

Tutorial for the development of new agricultural management rules to be included into BioMA software

This document provides a step-by-step guide for the extension of the CRA.AgroManagement.Rules component via the INRA.DMN.DSS.AgroManagement.Rules component we developed during the training.

Develop the algorithm of the rule

If you want to add a new rule to the component, you should firstly develop the algorithm in mind, defining which are the inputs actually required by the new rule.
As an example, the description of the rule we added together during the meeting was:
"The check on the new rule for sowing will start in October. A number of days after the first significant rainfall there is tillage. A number of days after tillage, the computation of the amount of rainfall and ETP starts. When the calculated amount of rainfall is larger than a percentage of ETP, than the climate conditions are favorable. Starting from this date, when soil water content in the first 10 cm is below a threshold, then there is sowing"
When the rule is defined, a good practice is to fill a table in which the inputs and the parameters of the rule are listed. In the former case, we will have

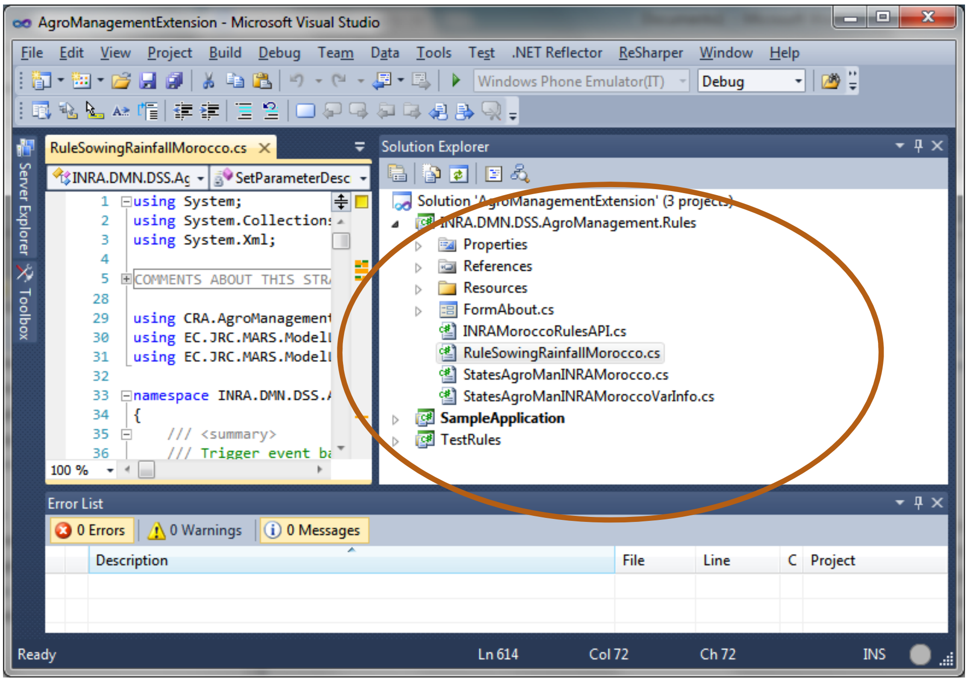
INPUT	PARAMETERS
Rainfall	RelativeDateStart
Evapotranspiration	RelativeDateEnd
Volumetric field capacity	Significant rainfall
Volumetric water content	No. days after tillage to start the rule
Day of the year	No. days after first rain for tillage
	Percentage of evapotranspiration
	Percentage of field capacity
	Rotation year

When these steps are fulfilled, then you can start to write the code.

How to add a new rule into the INRA.DMN.DSS.AgroManagement.Rules component

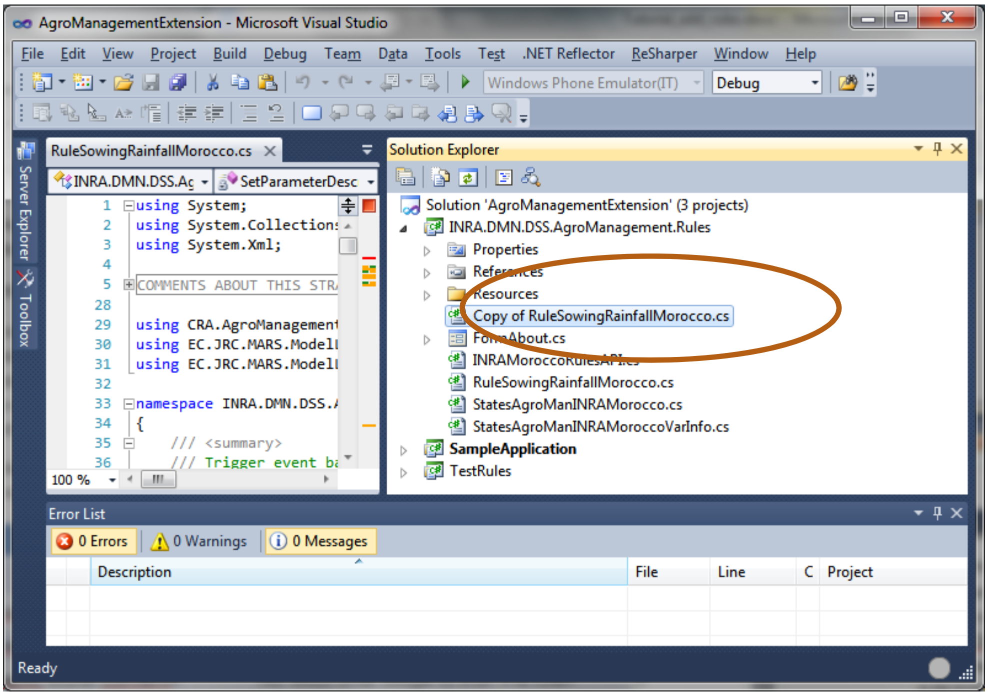
The correct sequence of steps to write a new rule follows:

1. Open the "*AgroManagementExtension.sln*" file with Visual Studio C#. During the meeting we used the Express Edition of Visual Studio, which is free and it can be operatively used.
2. In the Solution Explorer window, you will find 3 Visual Studio projects:
    a. "*INRA.DMN.DSS.AgroManagement.Rules.csproj*" which is the component we started to develop during the meeting;
    b. "*SampleApplication*" which is a console application project which read a meteorological file and test the rules on a 10-years simulation;
    c. "*TestRules*" which is a console application project which is used to test the rule with hard-coded input data.



3. Open the "*RuleSowingRainfallMorocco*" class: this code is fully commented and it represents the template to develop a new rule. Once you read the comments, please copy this file and add the copy to the same project (i.e., "*INRA.DMN.DSS.AgroManagement.Rules.csproj*")

4. Rename the copy of the "*RuleSowingRainfallMorocco*" file according to the new rule name.



5. If you try to compile the code now (Build/Build solution or F6), you will have errors due to the repeated class name: ***"Error 1The namespace 'INRA.DMN.DSS.AgroManagement.Rules' already contains a definition for 'RuleSowingRainfallMorocco'"***
6. Double click on the error. The code editor will move you to the rule name. You have to change it according to your needs.

7. Once done, please read the file and follow the instructions given by the comments to the code regions. E.g.,

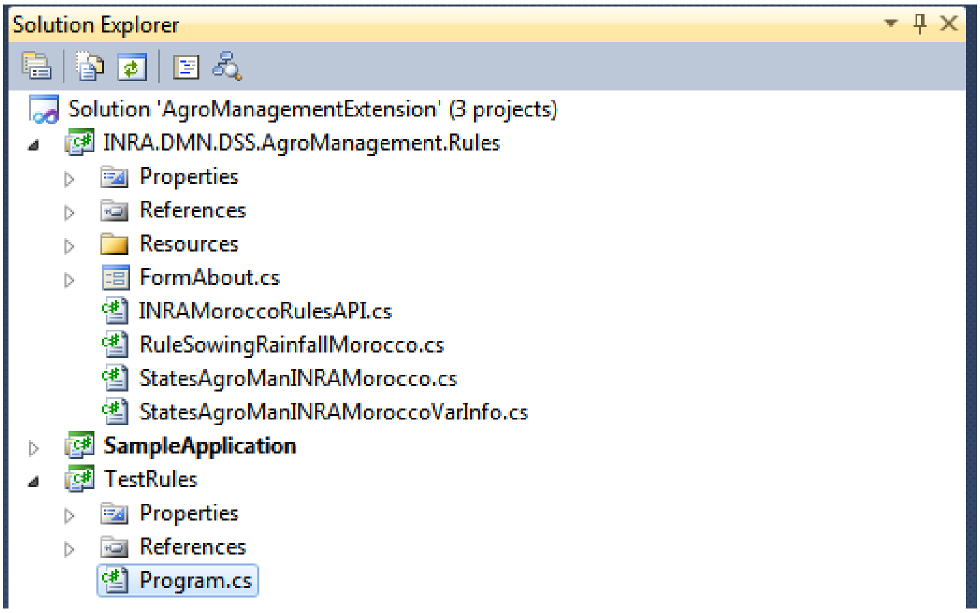
```
namespace INRA.DMN.DSS.AgroManagement.Rules
{
    /// <summary>
    /// Trigger event based on the Moroccan common agricultural management practices
    /// </summary>
    public class RuleSowingRainfallMorocco : IRules
    {
        //This is the constructor method, first overload. Please do not change
        static RuleSowingRainfallMorocco()...

        //This is the constructor method, second overload. Please do not change
        public RuleSowingRainfallMorocco()...

        These region contains the internal private variables of the rule

        Lists: Inputs, Parameters, description. In this region, you have only to change the model description

        Declaration of the parameters of the rule and of their VarInfo types.

        IStrategy Members. In this region you have to change only the Description

        IVarInfoClass Members. You do not have to change this region
```

8. By following these instructions, you should be able to complete the new rule. The implementation of the algorithm of the rule is done within the "*IRulesMember*" code region. Starting from the template, you have to write the new algorithm inside the "*CheckRule*" method:

```
        /// <summary>
        /// Rule model. This is the main part to change. The algorithm of the rule is implemented here
        /// </summary>
        /// <param name="st">Biophysical states of the system</param>
        /// <param name="m">Management parameters</param>
        /// <returns>True is rules are matched</returns>
        public bool CheckRule(StatesAgroMan st, IManagement m)
        {
            bool testRule = false;
            StatesAgroManINRAMorocco s = st as StatesAgroManINRAMorocco;

            /*This is the implementation of the algorithm of the rule. The description follows:
            The model for sowing will start after the RelativeDateStart parameter.
            A number of days after the first significant rainfall (FirstSignificantRain parameter) there is tillage (NumberOfDaysAfterFirstRainForTillage parameter).
            A number of days after tillage, the computation of the amount of rainfall and ETP starts (NumberOfDaysAfterTillageToStartTheRule parameter).
            When the calculated amount of rainfall is larger than a percentage of ETP (PercentageOfETP parameter),
            than the climate conditions are favorable.
            Starting from this date, when soil water content in the first 10 cm is below a threshold (ETPThreshold parameter), then there is sowing.
             */

            This is the algorithm of the rule
        }
```

How to test the new rule with hard coded input data (TestRules project)

1. Open the *Program* file of the *TestRules* project



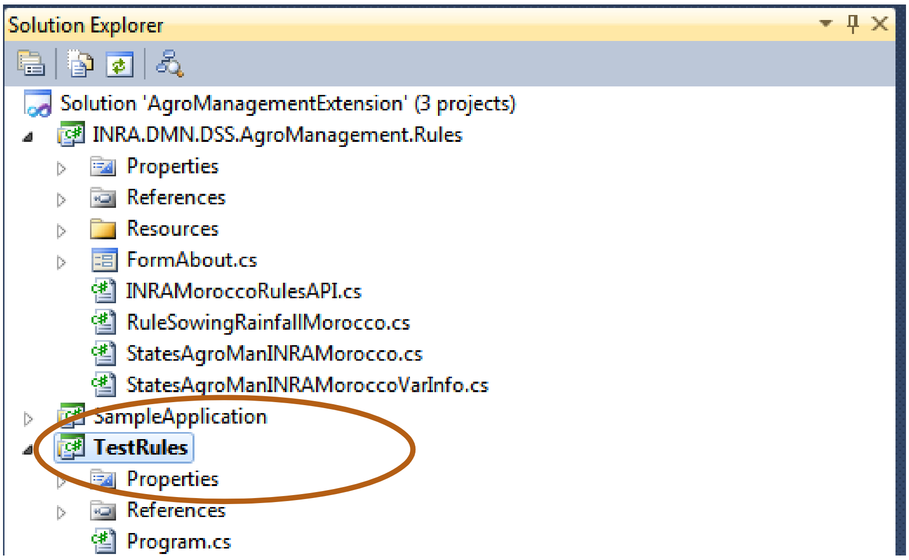
2. In this file you can find the method which tests the *RuleSowingRainfallMorocco* class. The method is called *TestRuleRainfallMorocco.* The code is fully commented:

```
        static void TestRuleRainfallMorocco()
        {
            //Set the input for the rule: AIR TEMPERATURE
            double[] _Rain = new double[] { 0, 0, 10, 20, 8, 6, 0, 0, 0, 50, 10, 10, 50, 10, 0, 10, 10};

            //states of agromanagement
            StatesAgroManINRAMorocco st = new StatesAgroManINRAMorocco();

            //Instance of soil layer object
            SoilLayer sl = new SoilLayer();

            //Valorize the soil water content and the field capacity of the first soil layer
            sl.SoilWaterContentVol = 0.3;
            sl.FieldCapacityVolSWC = 0.4;
            //Add the soil layer to the states of agromanagement
            st.SoilLayers.Add(sl);

            //Instance of the rule class
            RuleSowingRainfallMorocco sowTemp = new RuleSowingRainfallMorocco();

            //Valorize the parameters of the rule
            sowTemp.RotationYear = 1;
            sowTemp.RelativeDateStart = 2;
            sowTemp.RelativeDateEnd = 17;
            sowTemp.PercentageOfFieldCapacity = 0.8;
            sowTemp.PercentageOfETP = 0.5;
            sowTemp.NumberOfDaysAfterFirstRainForTillage = 2;
            sowTemp.NumberOfDaysAfterTillageToStartTheRule = 4;
            sowTemp.FirstSignificantRain = 20;
```

3. Copy the method below, and rename it as you prefer. Then valorize the inputs and the parameters using the copied method as a template.
4. Once finished, you have to add the new method name within the Main method, following the instructions. Then click on start debugging (Play button) to test the rule.

```
namespace TestRules
{
    class Program
    {
        static void Main(string[] args)
        {
            TestRuleRainfallMorocco();
            //new rule test should be placed here. Comment the line above if you want to test only the new rule
        }
```

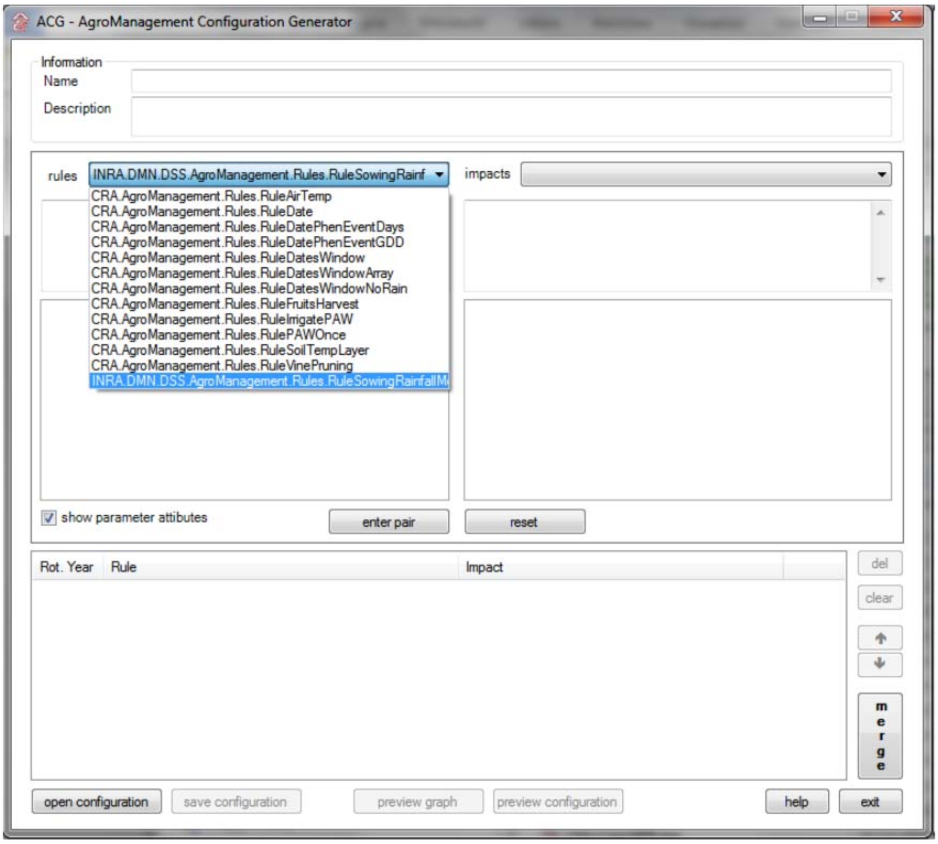
5. **IMPORTANT: if you want to test the new rule with hard coded input data, you have to set *TestRules* as startup project: left click on the project name, and select "Set as StartUp "project. The name of the project will appear in bold font:**



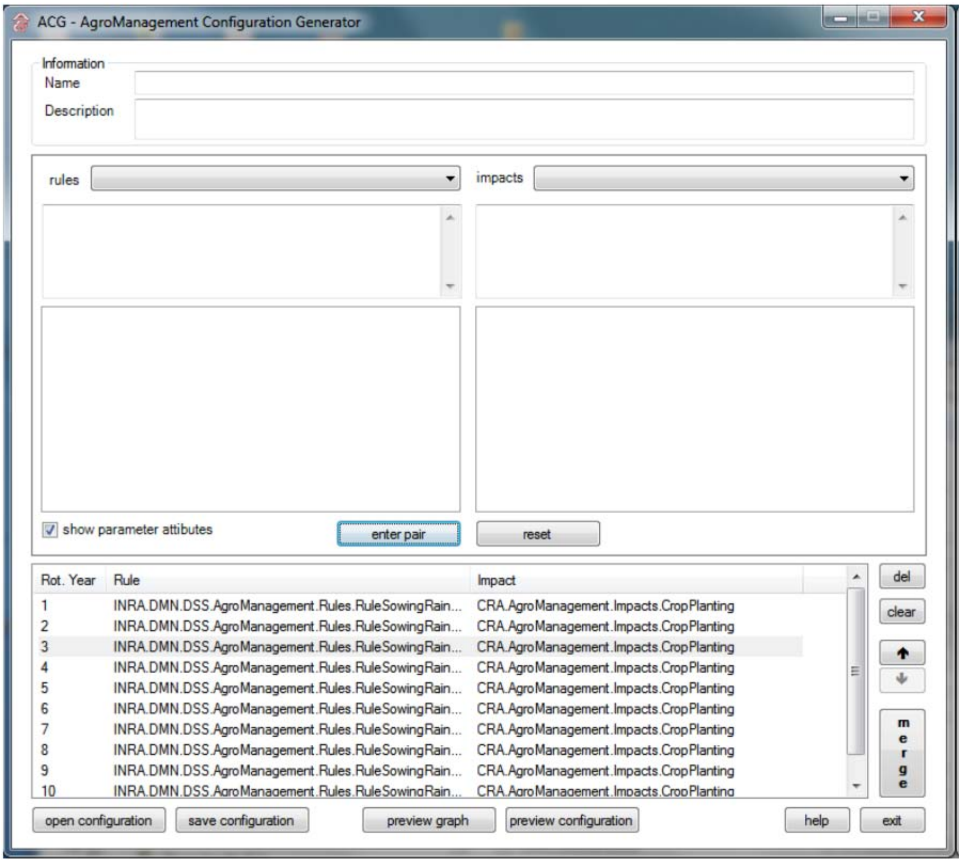
How to prepare the agromanagement file to test the rule on a long term period (Agromanagement Configurator Generator, ACG application)

After the test with hard coded input data is successful, you can develop a new agromanagement file to test the rule with the project SampleApplication:

1. Go to the path INRA.DMN.DSS.AgroManagement.Rules\bin\Debug and copy the file INRA.DMN.DSS.AgroManagement.Rules.dll. Check the date of creation of the file, it must correspond to the date and hour in which you performed the test;
2. Paste the dll in the path ACG application
3. Double click on the file CRA.AgroManagement.Configurator.exe in the same path ACG application. The ACG application will start.
4. By opening the menu Rules, the new rule will be available:



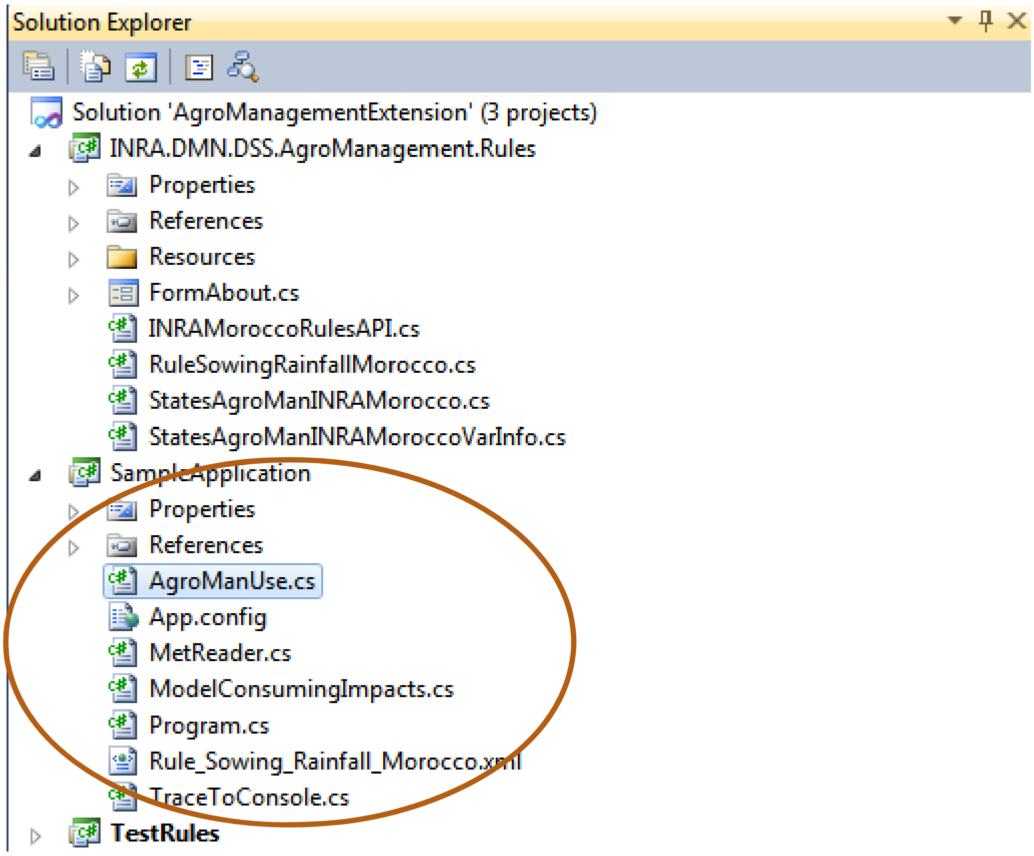
5. You can now couple this rule with an impact (e.g., CropPlanting) and repeat the rule to configure a 10 years period simulation:



6. You have to click on save configuration to create the agromanagement file containing the new rule. Please save the file in the *SampleApplication\bin\Debug* folder. In this example the file is named *template_rule_extension.xml*

How to test the new rule with a 10-years meteorological file (TestRules project)

1. Open the *AgroManUse* file of the *SampleApplication* project



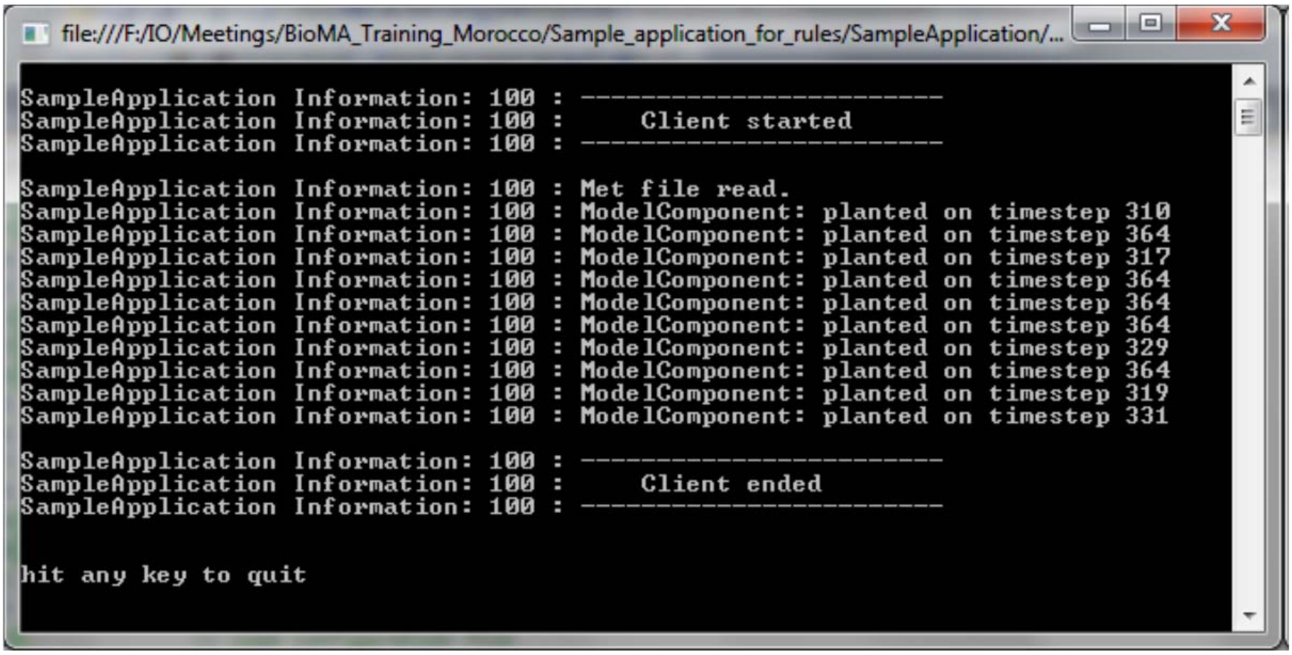
2. In this file you can find the code which reads the xml file template_rule_extension.xml and test the rule with a Moroccan meteorological file ("Morocco_sample_file.txt", which is in the SampleApplication\bin\Debug). When you have created the new file, you have to substitute the string template_rule_extension.xml with the new file name.

```
namespace SampleApplication
{
    internal class AgroManUse
    {

        #region Objects & Fields
        // AgroManagement API Application Programming Interface
        Scheduling sch = new Scheduling();

        // Returning obj with arrays of impacts
        ActEvents ae = null;

        // States of the physical system simulated
        INRA.DMN.DSS.AgroManagement.Rules.StatesAgroManINRAMorocco st = new INRA.DMN.DSS.AgroManagement.Rules.StatesAgroManINRAMorocco();

        // Modelconsuming impacts
        ModelConsumingImpacts m = new ModelConsumingImpacts();

        // AgroManagement sample configuration
        private string AgroManFile = "template_rule_extension.xml"; //"Rule_Fixed_Date.xml";

```

3. The method *Run*, which is implemented below, is the one used to test the rule. You have to check the comments above each code line and customizing it according to the inputs required by the new rule.

```
        //This method check the rule
        internal void Run()
        {
            //Create an instance of soil layer to test the rule
            SoilLayer sl = new SoilLayer();
            //Valorize the properties of soil layer
            sl.SoilWaterContentVol = 0.3;
            sl.FieldCapacityVolSWC = 0.4;
            sl.BulkDensity = 1;
            sl.WiltPointVolSWC = .2;
            sl.LayerThickness = .2;
            //Add a soil layer to the states of agromanagement
            st.SoilLayers.Add(sl);

            // Load configuration file
            sch.InitManagement(AgroManFile, true);

            //Istance of MetReader class (to read the meteorological file)
            MetReader met = new MetReader("Morocco_sample_file.txt");

            //years loop
            for (int year = 0; year < 10; year++)
            {
                //days loop
                for (int day = 1; day < 365; day++)
                {
                    // Assign time
                    CRA.AgroManagement.CurrentTime.RotationYear = year+1;
                    CRA.AgroManagement.CurrentTime.CurrentDay = met.DayOfYear[year, day];

                    // Assign values to states
                    st.AirTemperatureAverage = (met.AirMinimumTemperature[year, day] + met.AirMaximumTemperature[year, day]) / 2;
                    st.Rain = met.Rain[year, day];
                    st.PotentialEvapotranspiration = 2;

                    // Test rules
                    ae = new ActEvents();
                    ae = sch.CheckManagement(st, "day: " + day.ToString());

                    // Fire event if at least one rule matched
```

4. Once finished, click on the play button (Start debugging, F5). The code will test the new rule and a console application will help you to understand the outputs of the rule. In this case, the sowing date is reported for each year tested.



When you have tested the new rule, you have to copy the new file INRA.DMN.DSS.AgroManagement.Rules.dll in the BioMA folder, then you can use it by configuring the agromanagement file. The impact of the rule we developed during the training is shown in the picture below: different sowing dates are simulated according to the agrometeorological conditions experienced by the crop:

9. Appendix F

Minutes of the discussion on the BioMA training held at the University of Milan from 9th to 13th December 2013

Milan, 13/12/2013

Participants: Tarik El Hairech (DMN), Samira Ismaili (INRA), Valentina Pagani (UNIMI), Simone Bregaglio (UNIMI), Caterina Francone (UNIMI), Roberto Confalonieri (UNIMI)

Roberto Confalonieri: in China (December 2012) and Rabat (March 2013) we organized the first and the second training on BioMA. During this week we carried out a second step: an in-depth training about the use of the platform to explain users how to customize it for management and diseases. The third step would be to explain users how to develop new models, extend components and calibrate models, change algorithms, create components and add them into BioMA. Third step would need a longer period to develop new components (remember there are supporting tools for it that automatically implement 90% of the code, aside from input/output variables and equations). This third step would require one month fully working. For Hessian fly, in March we can stay in Morocco one week more to start planning the model, formalize your knowledge, and a PhD student could stay in Milan for 1 month to develop together the component. We received high quality data so we can plan to test the component against these data. Let's work together on it.

Tarik El Hairech: We aim at improving the CGMS forecasting system including the Diseases component, and we want to implement it in the next months in our system (before the training of the next year). Since the output structure is the same, it would not be a big problem.

Roberto Confalonieri: The portable database is similar to the Oracle one. The Disease component was not mentioned in the E-AGRI project.

Simone Bregaglio: Lets define the information I need to properly use the data you supplied me: longitude and latitude of the experimental site, sowing date for each site, reference scale for the severity inputs

Roberto Confalonieri: We already did in China with potential and disease limited. Here we have two models and three parameterizations files (durum, soft high, soft low). Barley is not included, but if you want, you can develop parameterizations.

Tarik El Hairech: We want to develop decision supporting system with meteorological forecast (about 5 days) to drive and optimize agromanagement practices.

Roberto Confalonieri: the same system can be used for forecast, early warnings, and to develop a DSS with meteorological forecasting.

Samira Ismaili: I want to start my PhD on an early warning system in climate change context.

Roberto Confalonieri: we have an FP7 project to develop three different scales of early warning systems with different information (remote sensing….) There are some models very simple for early warning. Some examples are given by the University of California UC IPM http://www.ipm.ucdavis.edu/ Do you agree?

Samira Ismaili and Tarik El Hairech: We learned a lot in these 4 days.

Roberto Confalonieri: During this training you learned how to extend the Agromanagement component. In the next days we will compile a new dll called *INRA.DMN.DSS.AgroManagement* including the rainfall rule you have just developed. In this way, you can develop other rules by yourselves. Developing new impacts is more complex, it needs more time, but the most important impact are already implemented in BioMA.
Tarik El Hairech: is it possible to couple BioMA with forecasted weather?
Roberto Confalonieri: For sure, you have just to link the BioMA with the new database. We can deliver some basic information (if tomorrow is raining, then do not do something). We will see Riad in Wageningen and we will see you in March in Rabat.
SUGGESTIONS and QUESTIONS
Tarik El Hairech: The portability of the SQL Server CE database makes some difficulties for simple users. It seems it is not optimized in writing results, also because the query are slow and often cause the BioMA application not answering. A solution can be link the laptop to the server.
Tarik El Hairech and Samira Ismaili: How to launch multiple simulations with BioMA?
Roberto Confalonieri and Simone Bregaglio: If you want to run BIOMA in batch, you can take the modelling solutions and write a sample applications (as the console application we developed yesterday for Diseases). Use the Model Parameter Explorer application (MPE) to edit parameter files (.XML).
Tarik El Hairech: Is BioMA portable on LINUX?
Roberto Confalonieri: No, it is not.