Crop Monitoring as an
E-agricultural tool in
Developing Countries

REPORT ON BIOMA WORKSHOP

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1.0	16/03/2013			Qinghan Dong

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 linked to a cascading approach for soil water redistribution. The workshop revealed a good degree of satisfaction for participants, and gave to the trainers important indications on how to organize the following meetings.

NOTE:
The deliverable corresponding to this report (D71.2) is scheduled for month 36. This version of the report refers only to the first BioMA workshop, held in Nanjing (People's Republic of China) during 10-12 December 2012, coorganized by Jiangsu Academy of Agricultural Sciences and University of Milan. This report will be integrated in the next months, after the other BioMA workshops will take place.
This strategy – i.e., submitting partial versions of the deliverable, each integrating the previous one – is due to an explicit request form the Project Reviewers, to avoid an accumulation of too many reports to be reviewed in the last months of the Project.

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 systems 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).

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 co-organized 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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wangzm69@126.com
qinghan.dong@vito.be

Preliminary Programme

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

<u>December 10th – Second Progress meeting E-AGRI</u>

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**

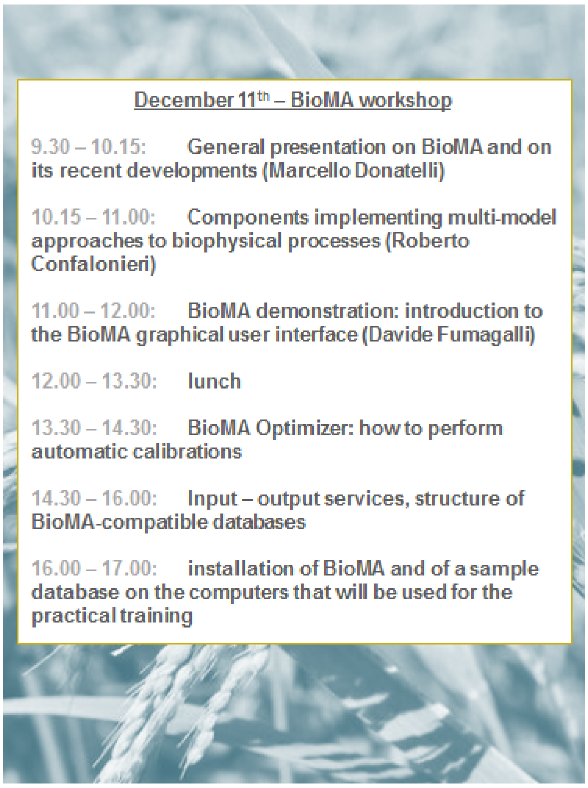
13.30 – 15:00: **presentations from WP leaders continued (WP5 to WP7)**

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


December 11th – BioMA workshop

9.30 – 10.15: General presentation on BioMA and on its recent developments (Marcello Donatelli)

10.15 – 11.00: Components implementing multi-model approaches to biophysical processes (Roberto Confalonieri)

11.00 – 12.00: BioMA demonstration: introduction to the BioMA graphical user interface (Davide Fumagalli)

12.00 – 13.30: lunch

13.30 – 14.30: BioMA Optimizer: how to perform automatic calibrations

14.30 – 16.00: Input – output services, structure of BioMA-compatible databases

16.00 – 17.00: installation of BioMA and of a sample database on the computers that will be used for the practical training


December 12th – BioMA workshop

09.30 – 12.00: Practical training on BioMA

12.00 – 13.30: Lunch

13.30 – 15.00: The Statistical toolbox (Allard de Wit)

15.00 – 16.00: Discussion and closure of the meeting (chairman: Qinghan Dong)

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
Rachid Hadria	Institut National de la Recherche Agronomique (INRA), Maroc	r.hadria@gmail.com
Hassan Benaouda	Institut National de la Recherche Agronomique (INRA), Maroc	hbenaouda_inra@yahoo.fr
Ismaili Samira	Institut National de la Recherche Agronomique (INRA), Maroc	Ismaili.samira@gmail.com
Chen Zhongxin	Institute of Agricultural Resources & Regional Planning, Chinese Academy of Agricultural Sciences (CAAS), China	ifvsxn@gmail.com
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Jiang Xudong	Anhui Institution for Economic Research (AIER), China	ahgisjxd@163.com
Yang Qing	Anhui Institution for Economic Research (AIER), China	yangqinghust@gmail.com
Zhang Beier	Anhui Institution for Economic Research (AIER), China	bellzhang@yahoo.com
Sun Ling	Institute of Agricultural Economics and Information, Jiangsu Academy of Agricultural Sciences (JAAS), China	sunling@jaas.ac.cn
Wang Zhiming	Institute of Agricultural Economics and Information, Jiangsu Academy of Agricultural Sciences (JAAS), China	wangzm69@126.com
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Yu Kun	Institute of Agricultural Economics and Information, Jiangsu Academy of Agricultural Sciences (JAAS), China	yukun108@gmail.com
Wang Jingjing	Institute of Agricultural Economics and Information, Jiangsu Academy of Agricultural Sciences (JAAS), China	lmmi103@163.com
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.

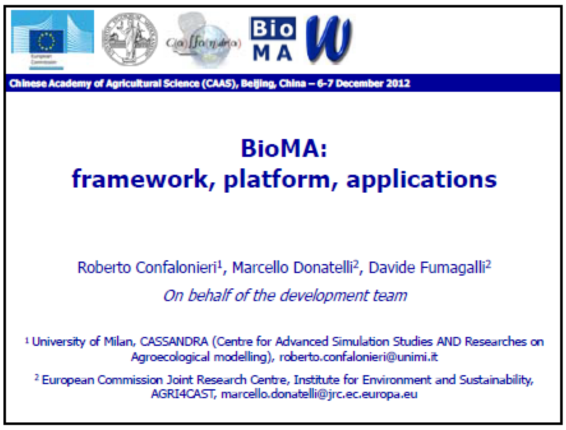
3. Conclusions

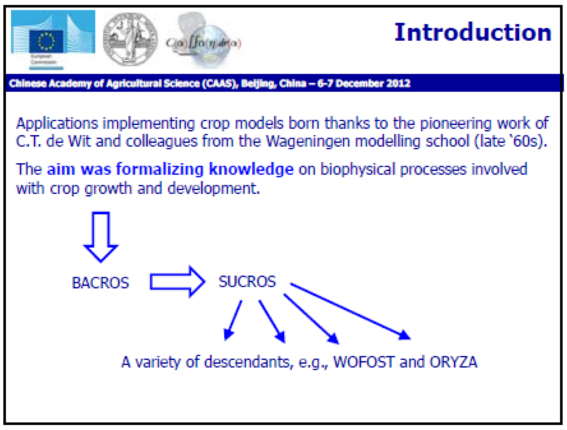
The first BioMA workshop allowed to effectively transfer the main conceptual and technical aspects behind the BioMA platform.

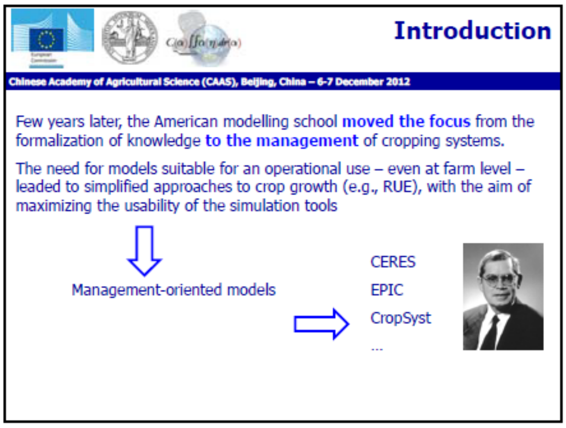
Participants understood and appreciated the potentialities of the platform and its novel approaches. Although such potentialities and the advanced technical features slightly increase the complexity for the user compared to classical tools, the efforts invested in designing and developing the graphical user interface led to a friendly environment, that did not create problems or obstacles to the training participants.

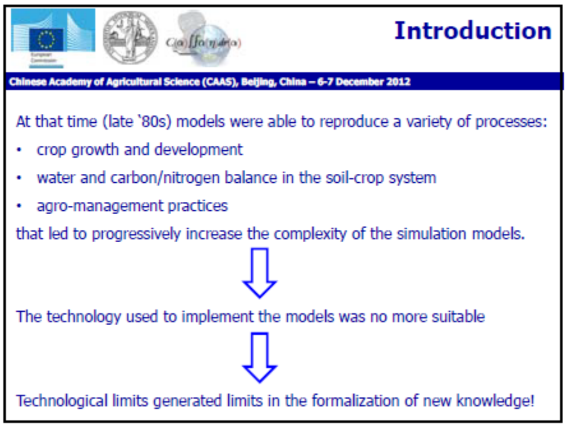
4. Appendix A

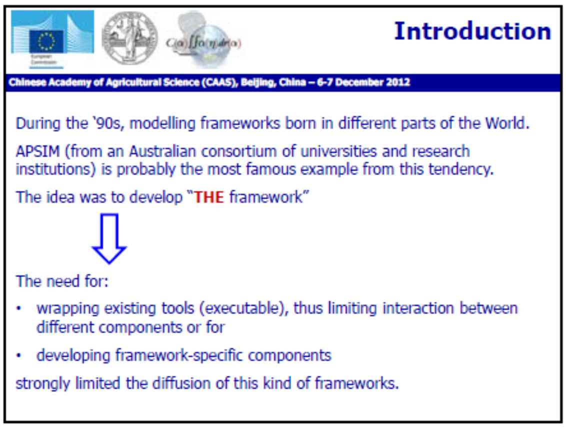
BioMA: framework, platform, applications

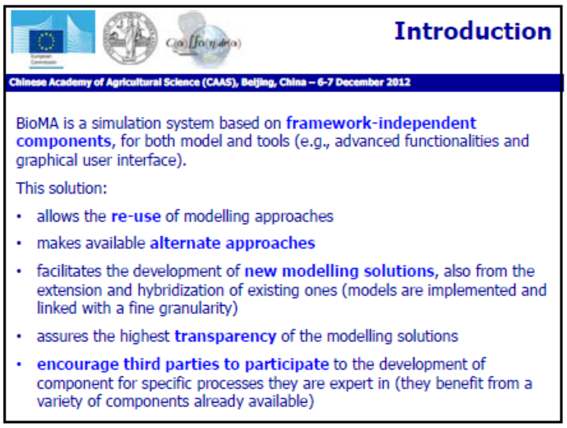

Bio MA
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
BioMA:
framework, platform, applications
Roberto Confalonieri[1], Marcello Donatelli[2], Davide Fumagalli[2]
On behalf of the development team
[1] University of Milan, CASSANDRA (Centre for Advanced Simulation Studies 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


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

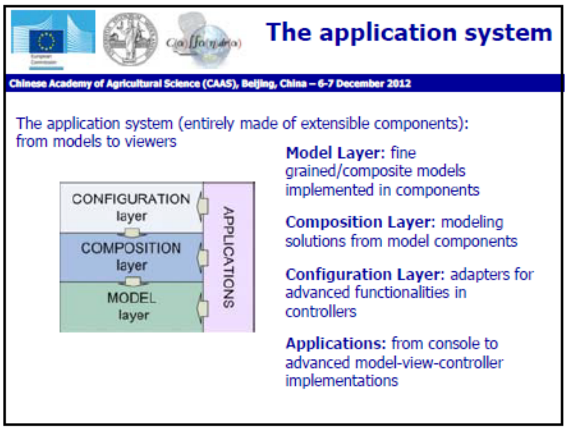

Introduction
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Few years later, the American modelling school moved the focus from the formalization of knowledge to the management of cropping systems.
The need for models suitable for an operational use – even at farm 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
…

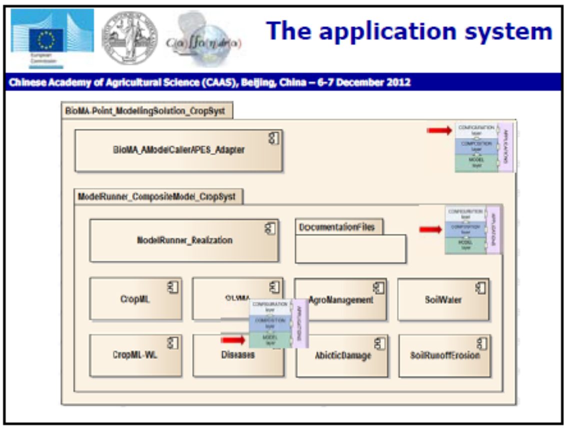

Introduction
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
At that time (late '80s) models were able to reproduce a variety of processes:
• crop growth and development
• water and carbon/nitrogen balance in the soil-crop system
• agro-management practices
that led 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!

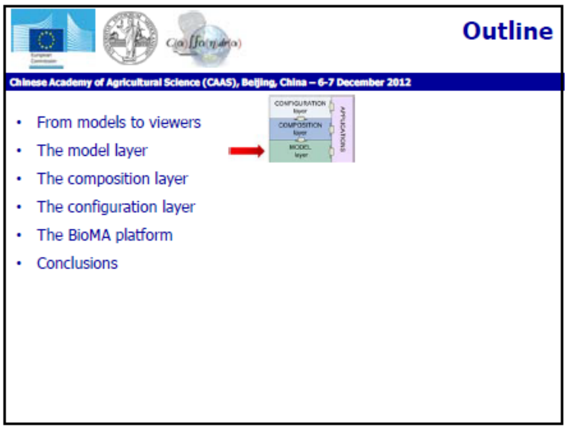

Introduction
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
During the '90s, modelling frameworks born in different parts of the World.
APSIM (from an Australian consortium of universities and research institutions) is probably the most famous example from this tendency.
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


Outline
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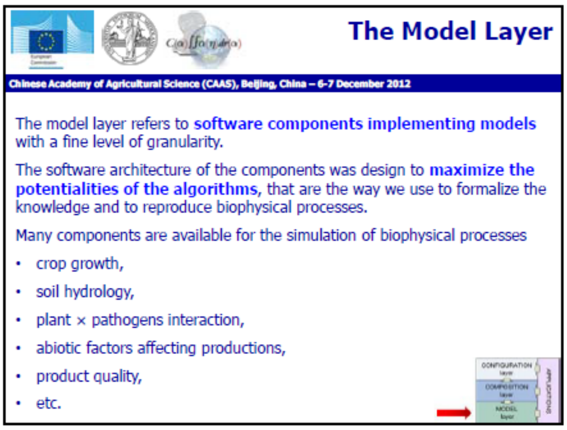
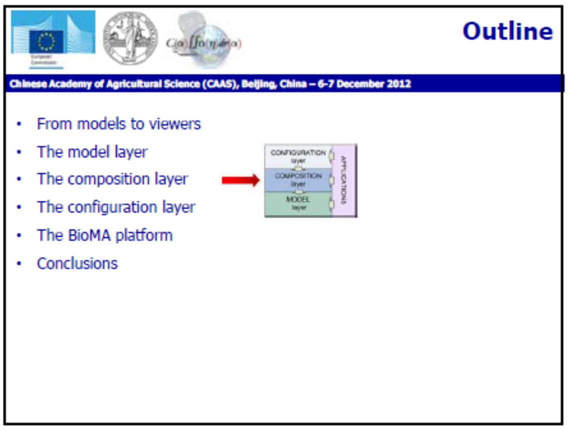

The Model Layer
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
The model layer refers to software components implementing models with a fine level of granularity.
The software architecture of the components was design to maximize the potentialities of the algorithms, 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.


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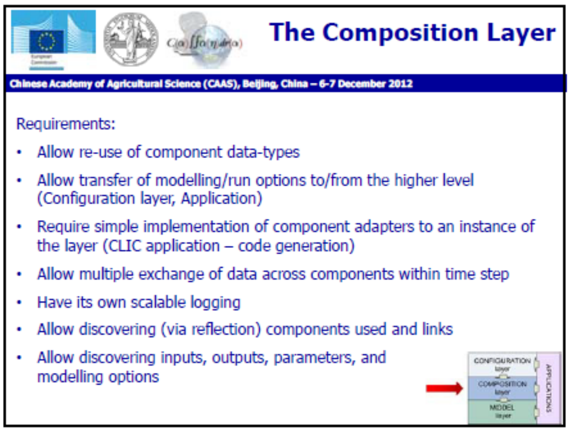
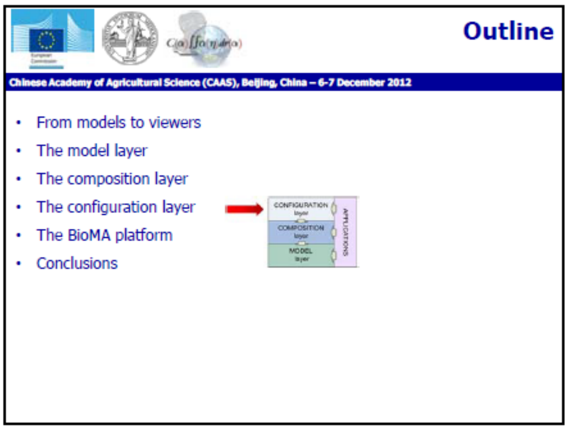
• Conclusions


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


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


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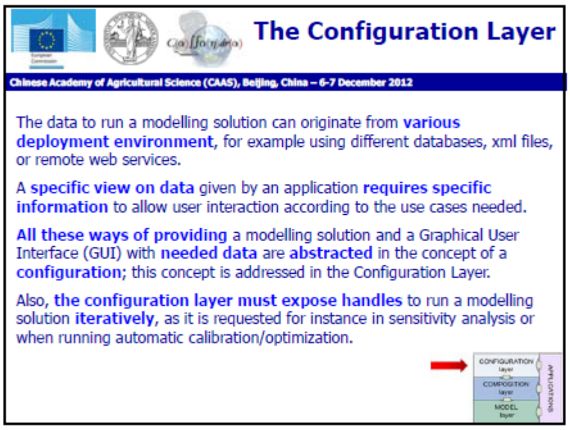
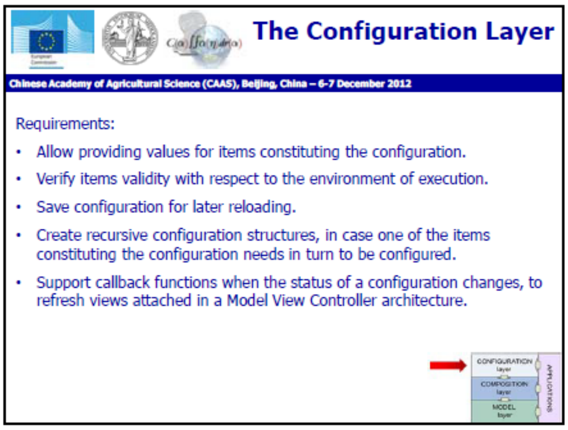
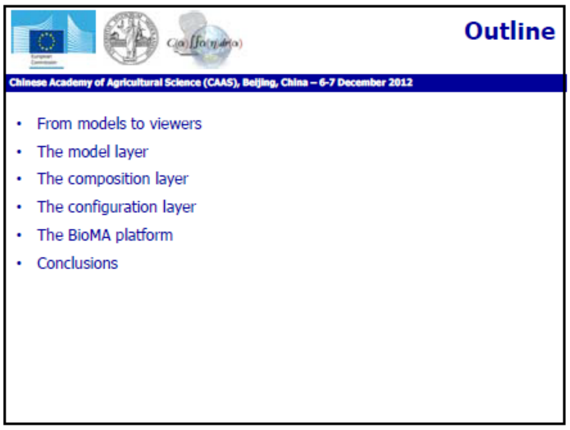
CONFIGURATION layer
COMPOSITION layer
MODEL layer
APPLICATIONS


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


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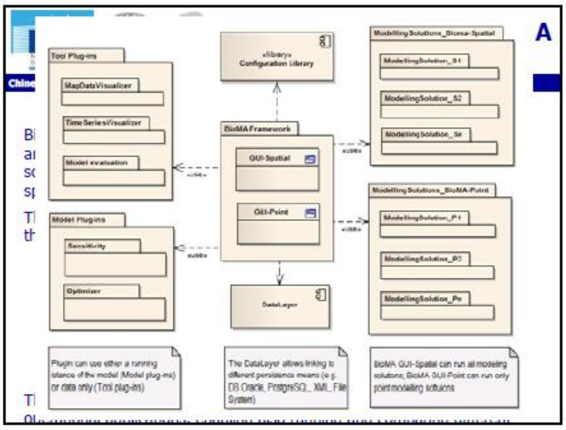
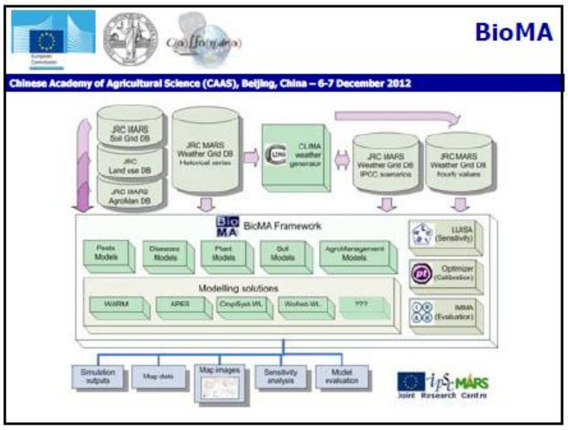
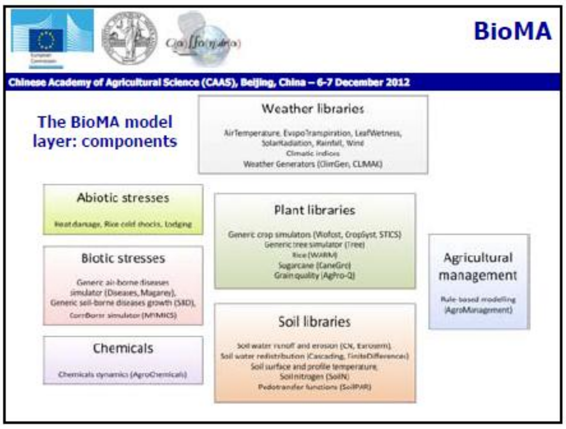
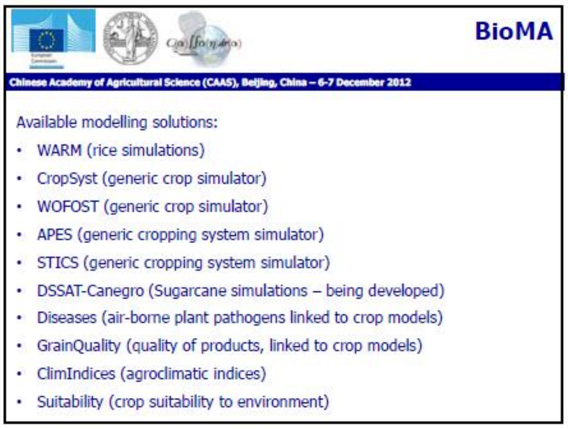
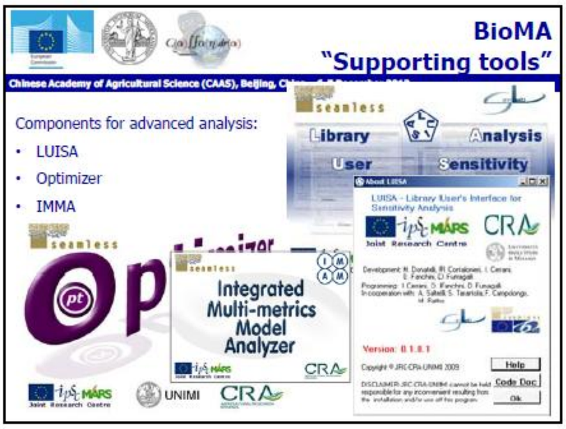
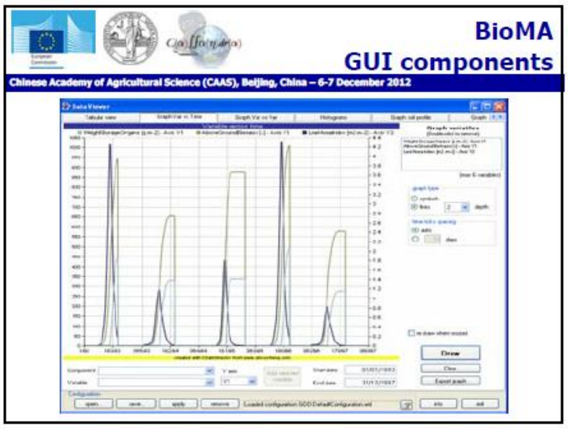

A
Tool Plug-ins
MapDataVisualizer
TimeSeriesVisualizer
Model evaluation
Model Plugins
Sensitivity
Optimizer
BioMA Framework
GUI-Spatial
GUI-Point
DataLayer
Plugin can use either a running istance of the model (Model plug-ins) or data only (Tool plug-ins)
BioMA GUI-Spatial can run all modeling solutions; BioMA GUI-Point can run only point modeling solutions

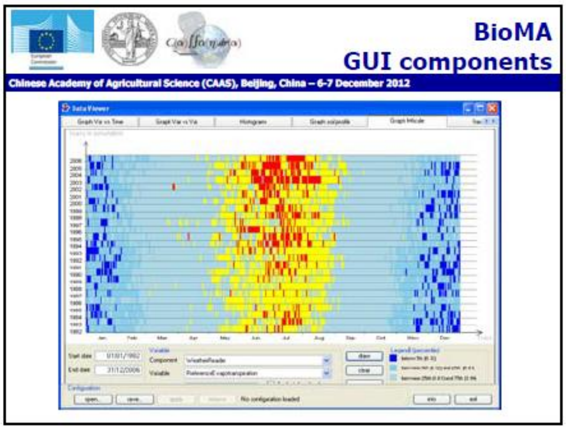

BioMA
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
BioMA Framework
Modelling solutions

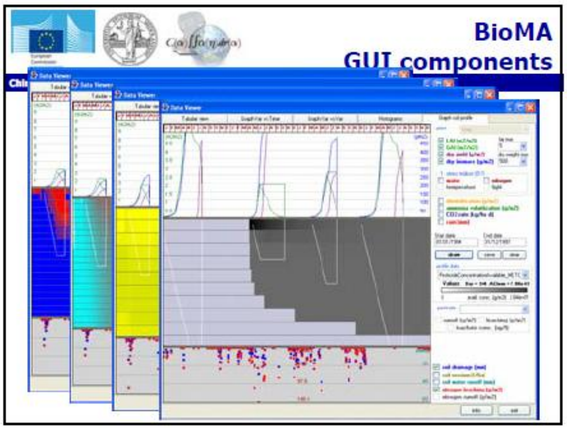

BioMA
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
The BioMA model layer: components
Weather libraries
Abiotic stresses
Biotic stresses
Chemicals
Plant libraries
Soil libraries
Agricultural management

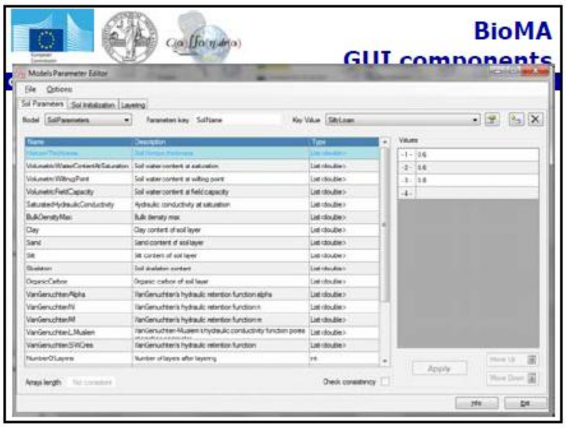

BioMA
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Available modelling solutions:
• WARM (rice simulations)
• CropSyst (generic crop simulator)
• WOFOST (generic crop simulator)
• APES (generic cropping system simulator)
• STICS (generic cropping system simulator)
• 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)

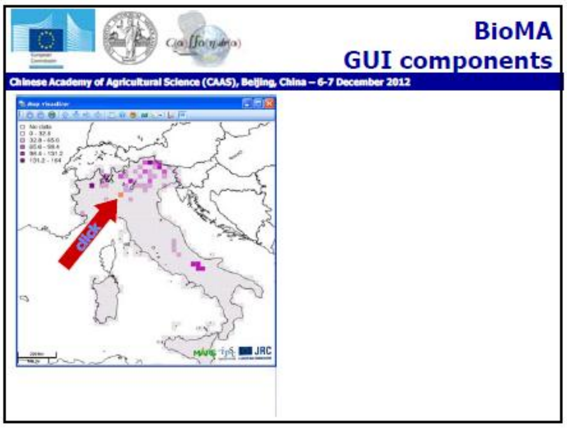

BioMA
"Supporting tools"
Components for advanced analysis:
• LUISA
• Optimizer
• IMMA
Library User Analysis Sensitivity
Integrated Multi-metrics Model Analyzer

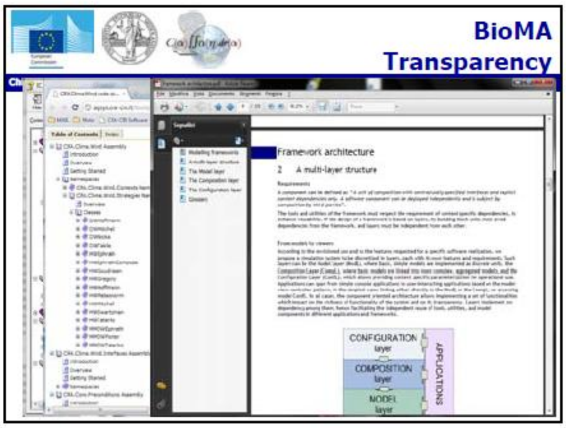

BioMA
GUI components
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012


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


BioMA
GUI components

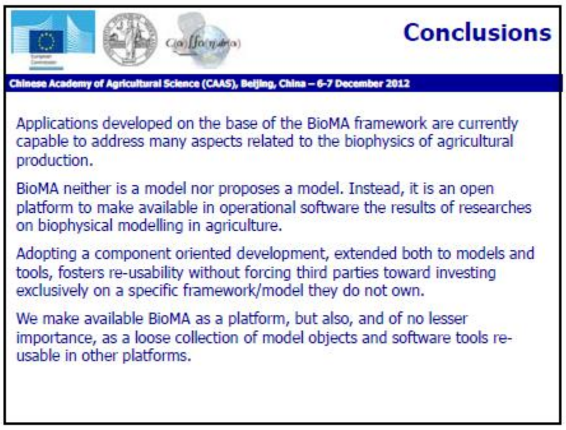

BioMA

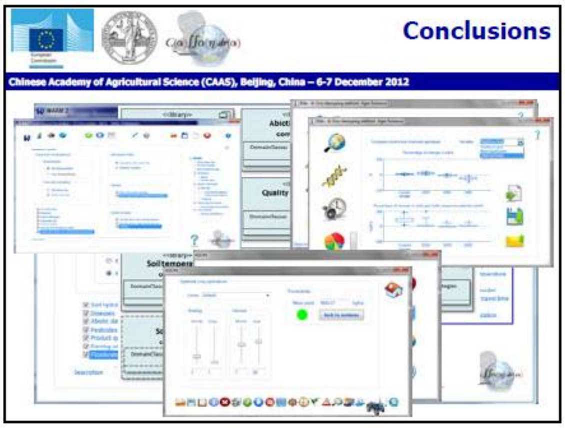

BioMA
GUI components
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012


BioMA
Transparency
Framework architecture


BioMA
Tools for Agro-Meteorology and Biophysical Modeling


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

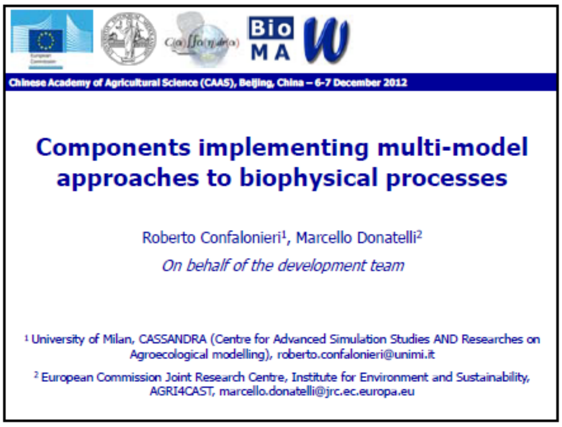

Conclusions
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Applications developed on the base of the BioMA framework are currently capable to address many aspects related to the biophysics of agricultural production.
BioMA neither is a model nor proposes a model. Instead, 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.

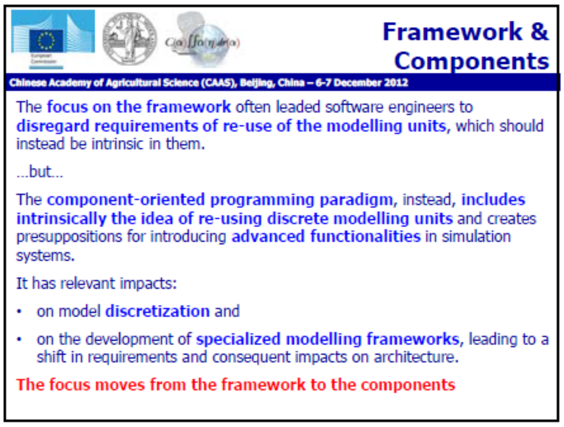

Conclusions
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012

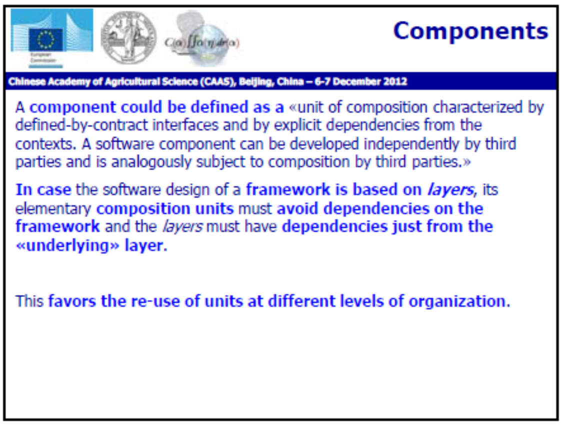

Many thanks for your kind attention

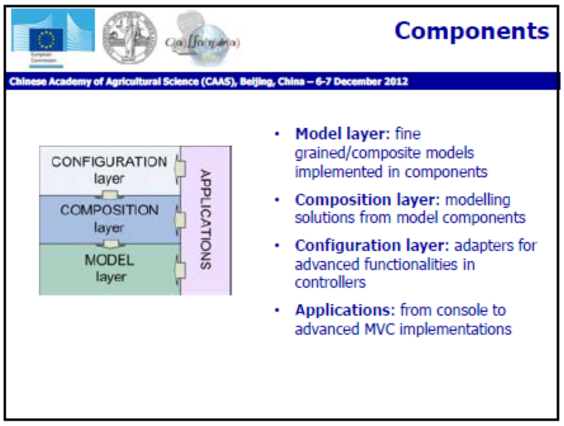
5. Appendix B

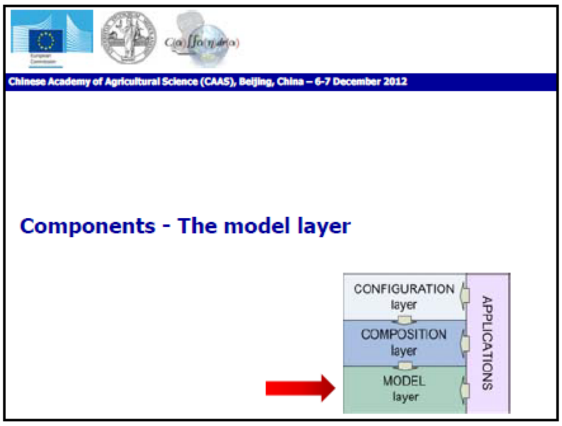
Components implementing multi-model approaches to biophysical processes

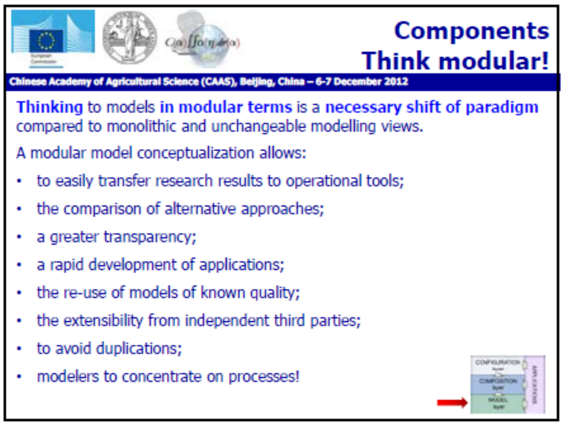

Bio MA
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Components implementing multi-model approaches to biophysical processes
Roberto Confalonieri[1], Marcello Donatelli[2]
On behalf of the development team
[1] University of Milan, CASSANDRA (Centre for Advanced Simulation 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

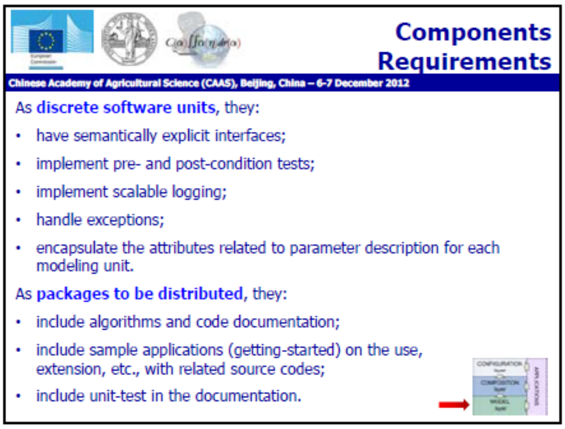

Framework & Components
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
The focus on the framework often leaded software engineers to disregard requirements of re-use of the modelling units, which should instead be intrinsic in them.
...but...
The component-oriented 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

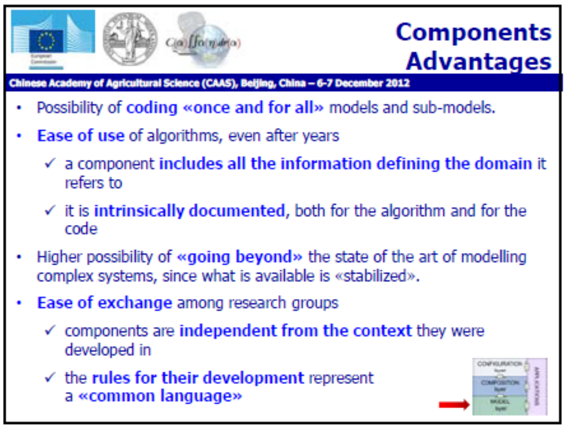

Components
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
A component could be defined as a «unit of composition characterized by defined-by-contract interfaces and by explicit dependencies from the contexts. A software component can be developed independently by third 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.

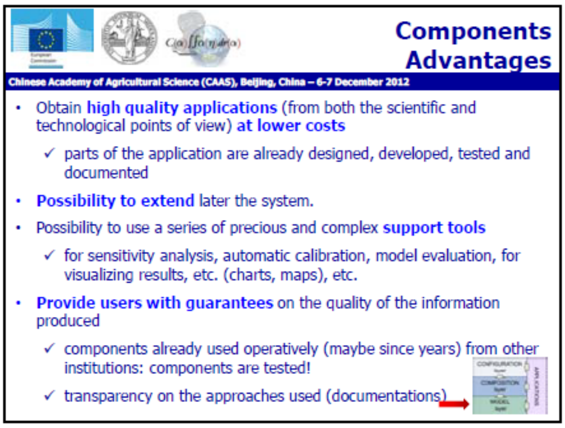

Components
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
CONFIGURATION layer
COMPOSITION layer
MODEL layer
APPLICATIONS
• Model layer: fine grained/composite models implemented in components
• Composition layer: modelling solutions from model components
• Configuration layer: adapters for advanced functionalities in controllers
• Applications: from console to advanced MVC implementations

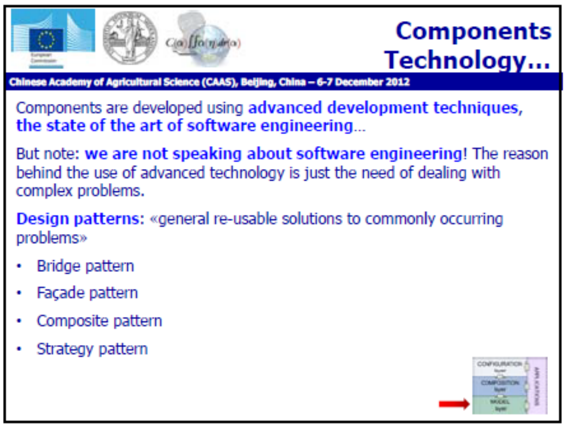

Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Components - The model layer
CONFIGURATION layer
COMPOSITION layer
MODEL layer
APPLICATIONS

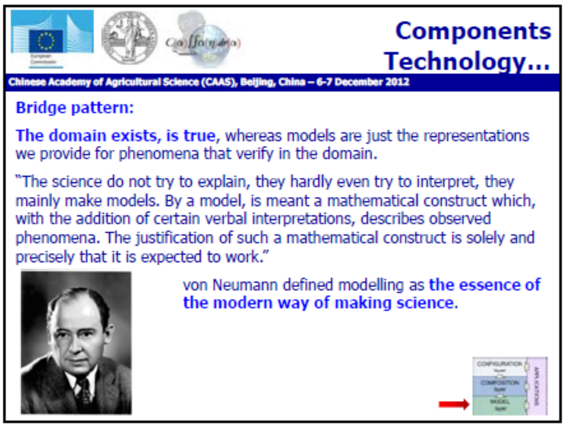

Components
Think modular!
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Thinking to models in modular terms is a necessary shift of paradigm compared to monolithic and unchangeable modelling views.
A modular model conceptualization allows:
• to easily transfer research 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!

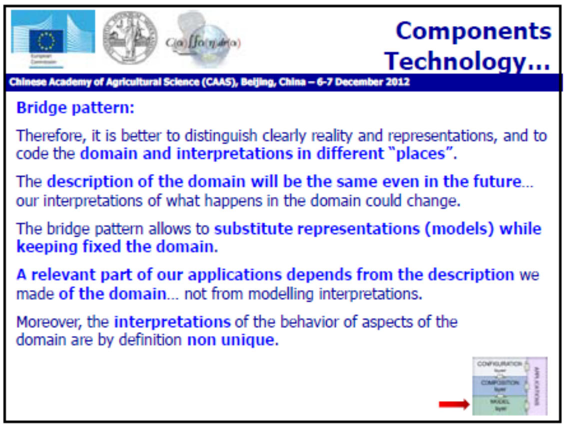

Components
Requirements
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
As discrete software units, they:
• have semantically explicit interfaces;
• implement pre- and post-condition tests;
• implement scalable logging;
• handle exceptions;
• encapsulate the attributes 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.

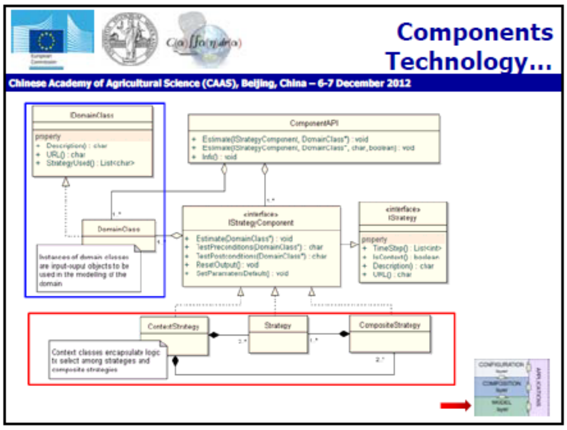

Components
Advantages
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
• Possibility of coding «once and for all» models and sub-models.
• Ease of use of algorithms, even after years
✓ a component includes all the information defining the domain it refers to
✓ it is 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»

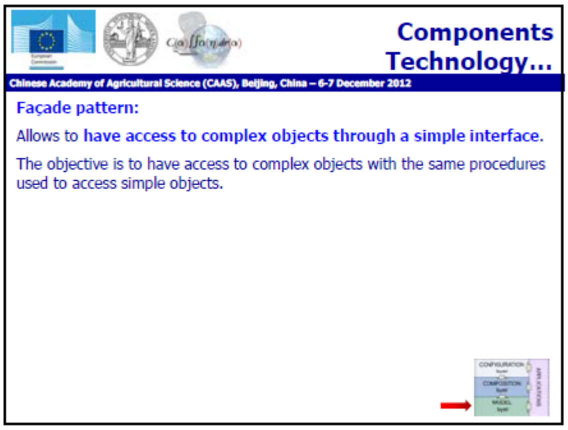

Components
Advantages
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
• Obtain high quality applications (from both the scientific and technological points of view) at lower costs
✓ parts of the application are already designed, developed, tested and documented
• Possibility 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)

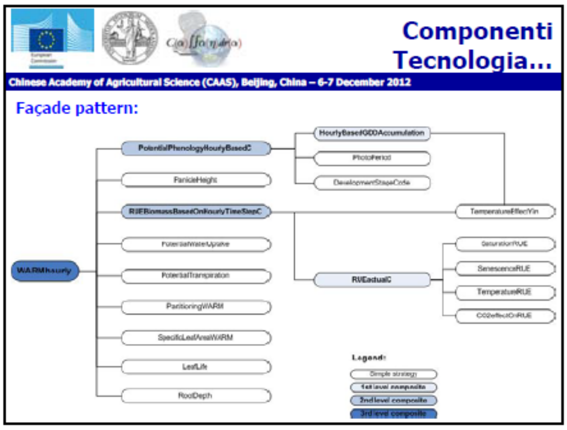

Components
Technology…
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Components are developed using advanced development techniques, the state of the art of software engineering…
But note: we are not speaking about software engineering! The reason behind the use of 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

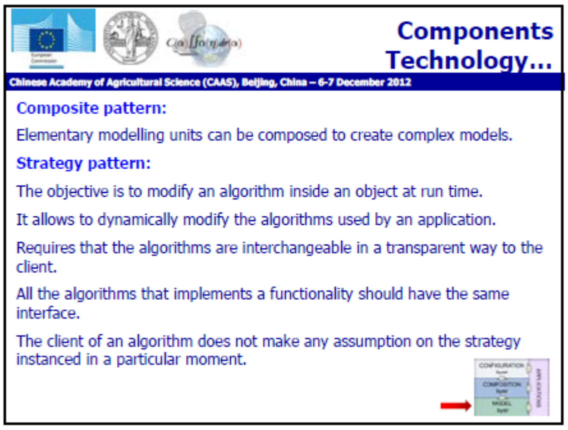

Components
Technology…
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Bridge pattern:
The domain exists, is true, whereas models are just the representations we provide for phenomena that verify in the domain.
"The science do not try to explain, they hardly even try 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.

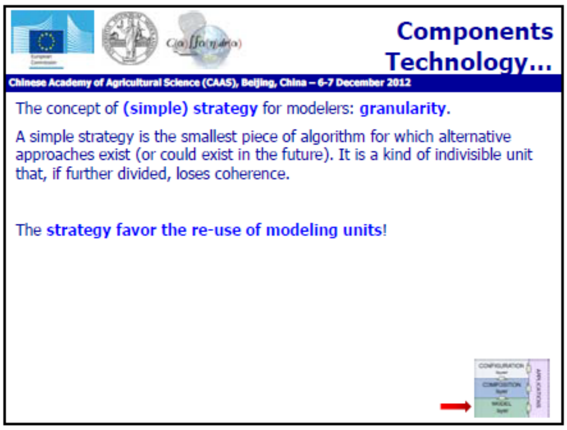

Components
Technology…
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Bridge pattern:
Therefore, it is better to distinguish clearly reality and representations, and to code the domain and interpretations in different "places".
The description of the domain will be 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.

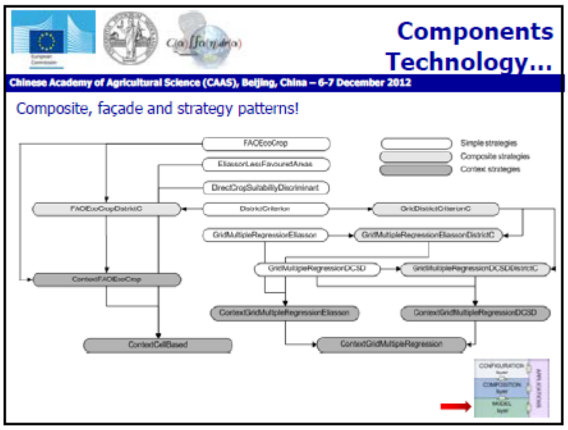

Components Technology…
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012

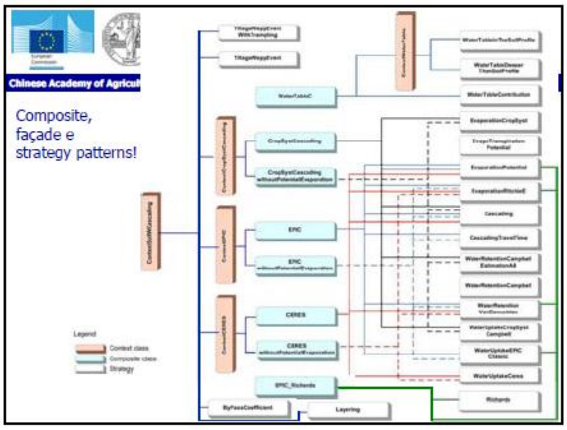

Components Technology…
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Façade pattern:
Allows to have access to complex objects through a simple interface.
The objective is to have access to complex objects with the same procedures used to access simple objects.

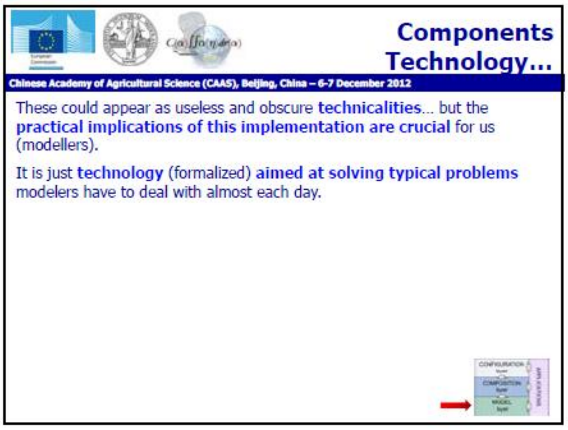

Componenti Tecnologia…
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Façade pattern:


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.

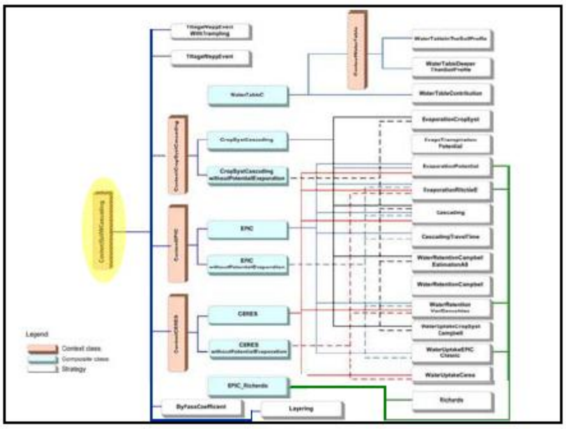

Components Technology…
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
The concept of (simple) strategy for modelers: granularity.
A simple strategy is the smallest piece of algorithm for which alternative approaches exist (or could exist in the future). It is a kind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

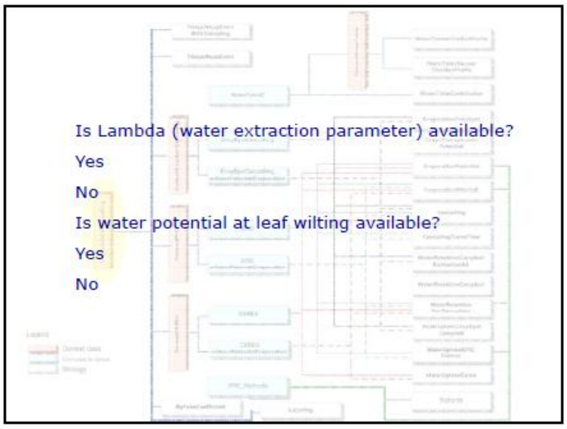

Components Technology…
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Composite, façade and strategy patterns!

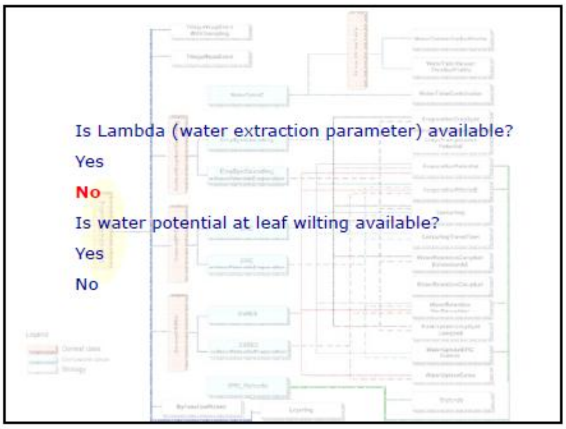

Chinese Academy of Agricul
Composite,
façade e
strategy patterns!
Legend


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)




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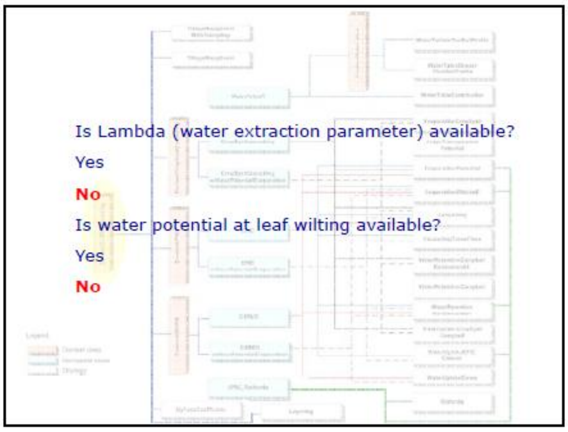
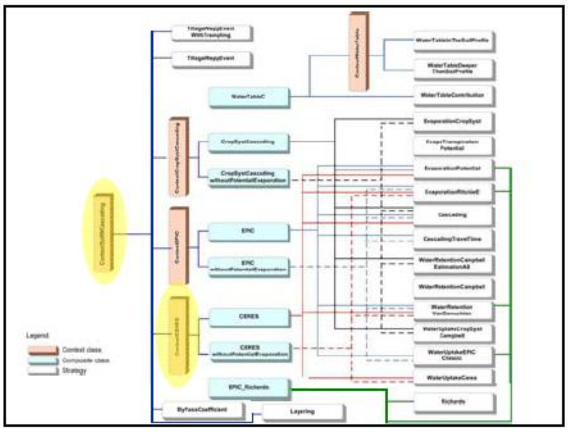
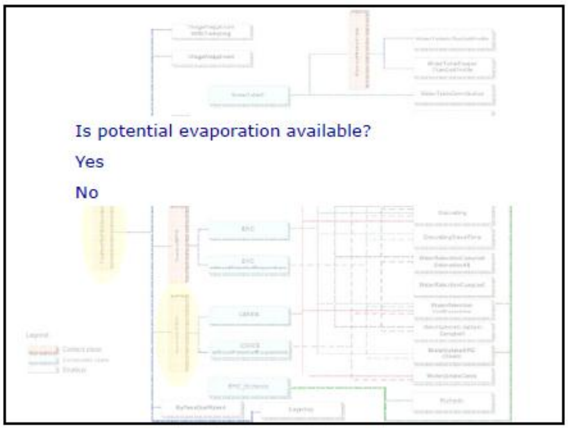
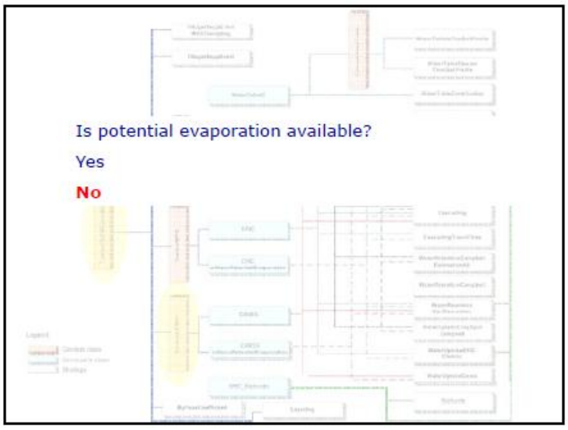
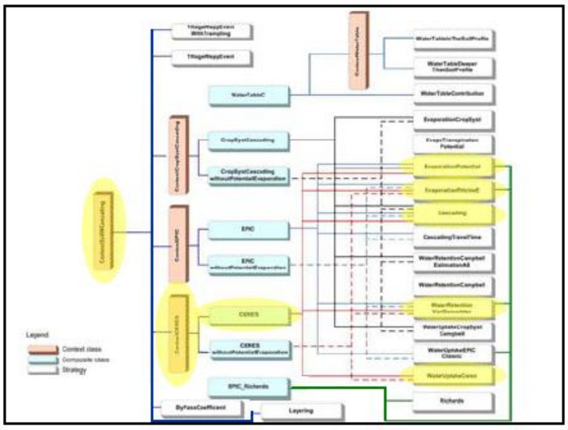
Yes
No
Is water potential at leaf wilting available?
Yes
No

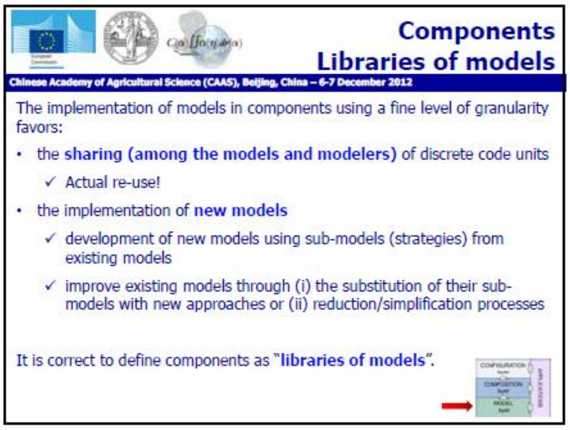

Is Lambda (water extraction parameter) available?
Yes
No
Is water potential at leaf wilting available?
Yes
No

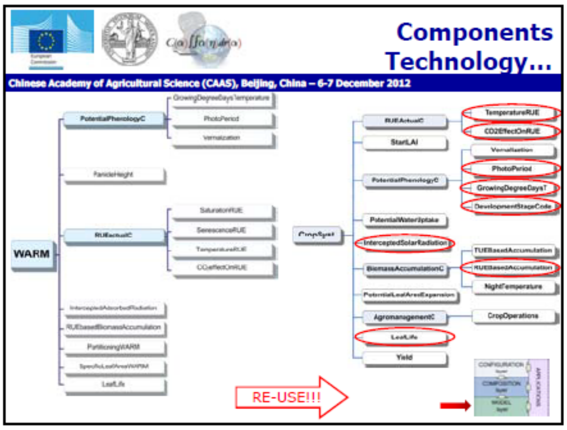


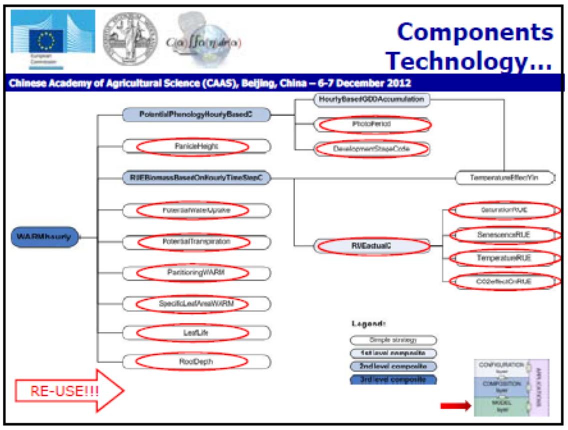

Is potential evaporation available?
Yes
No

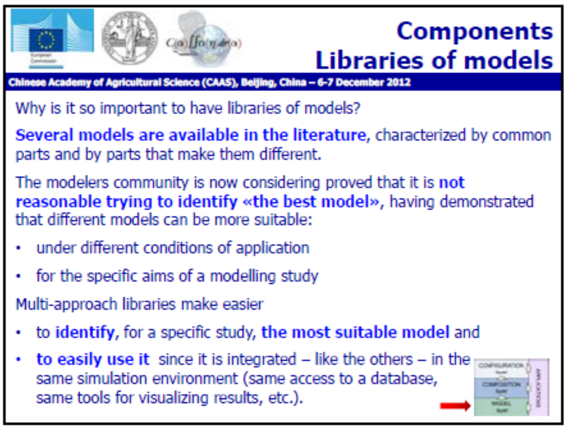

Is potential evaporation available?
Yes
No

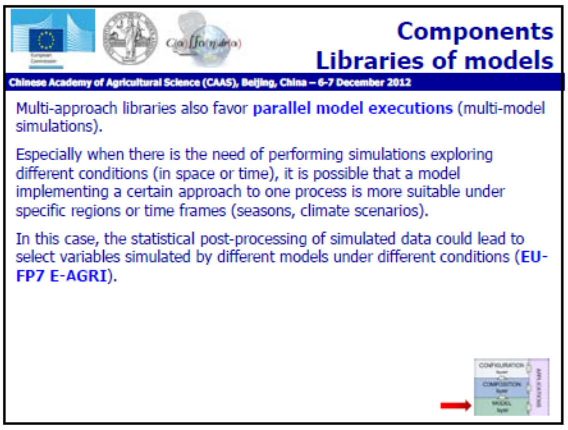


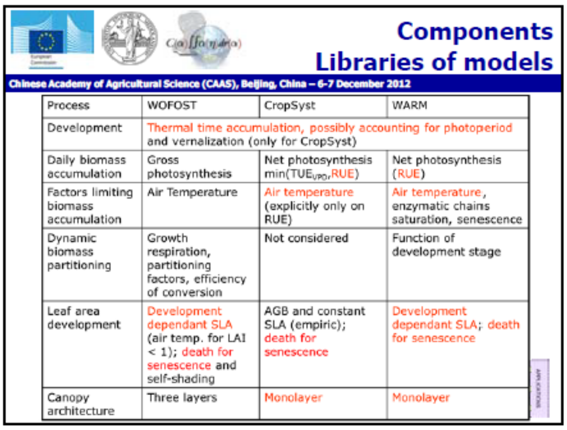

Components
Libraries of models
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
The implementation of models in components using a fine level of granularity favors:
• the sharing (among the models and modelers) of discrete code units
✓ Actual re-use!
• the implementation 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".



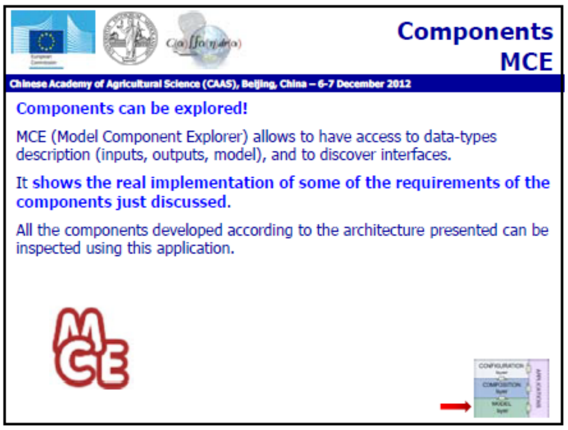


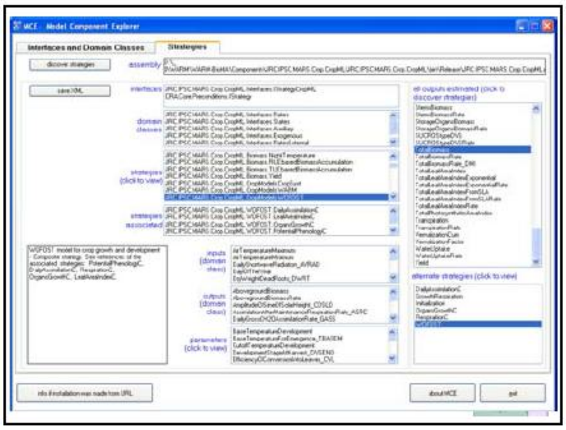


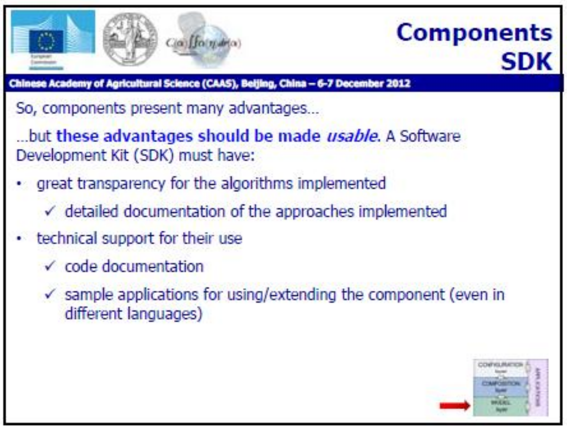


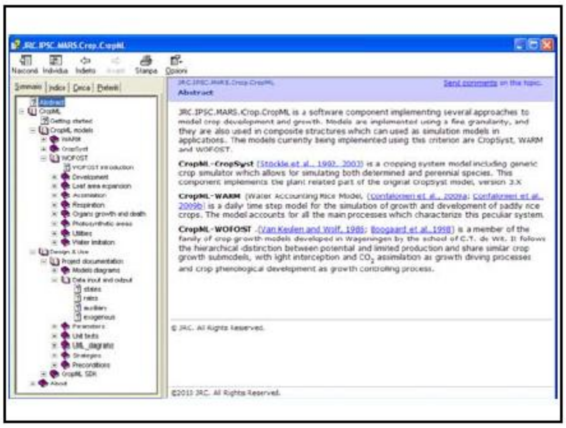


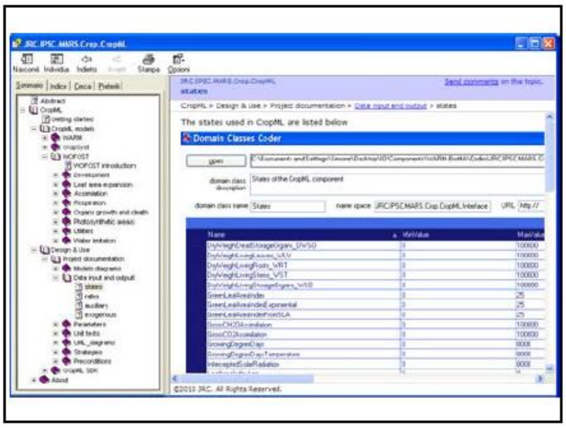
Process	WOFOST	CropSyst	WARM
Development	Thermal time accumulation, possibly accounting for photoperiod and vernalization (only for CropSyst)		
Daily biomass accumulation	Gross photosynthesis	Net photosynthesis min(TUE_{VPD},RUE)	Net photosynthesis (RUE)
Factors limiting biomass accumulation	Air Temperature	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

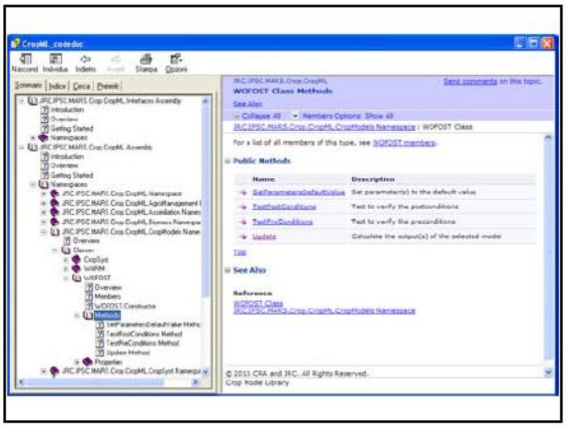


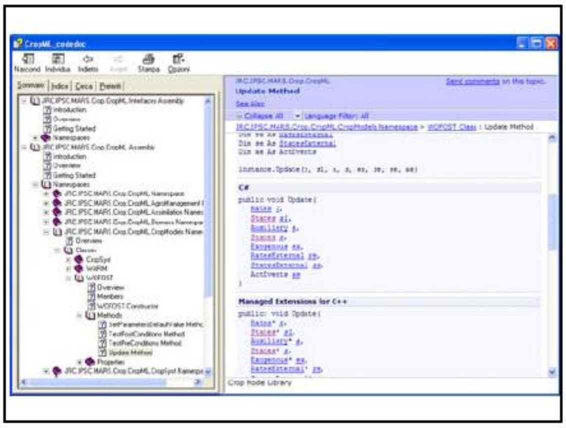


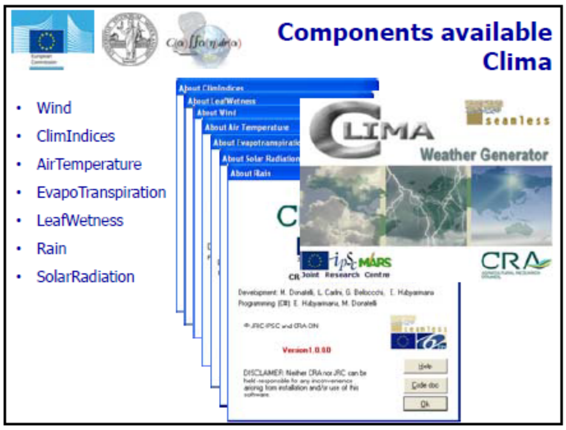

Components SDK
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
So, components present many advantages…
…but these advantages should be made usable. A Software Development Kit (SDK) must have:
great transparency for the algorithms implemented
detailed documentation of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

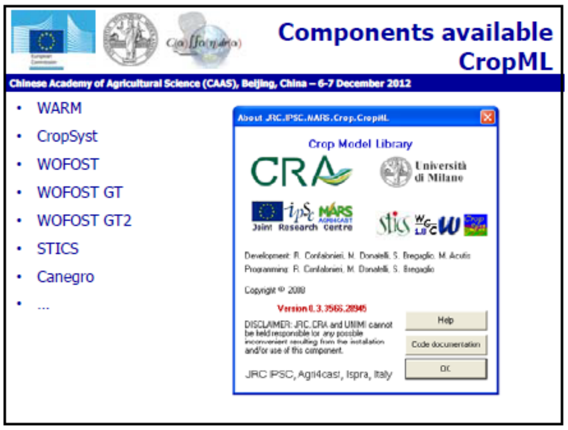




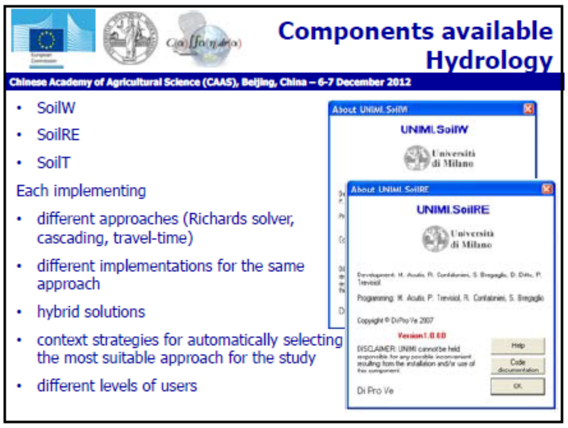


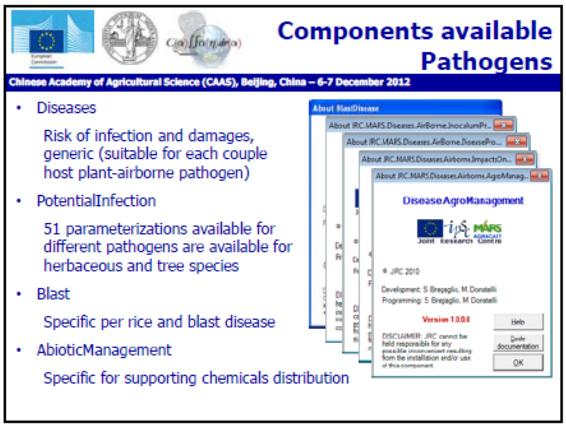


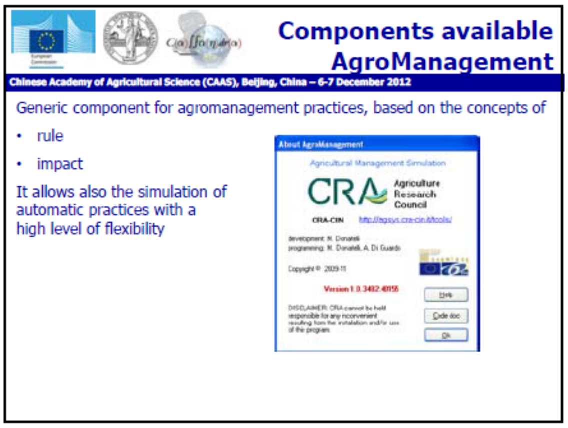

Components available
Clima
• Wind
• ClimIndices
• AirTemperature
• EvapoTranspiration
• LeafWetness
• Rain
• SolarRadiation
CLIMA
Weather Generator
seamless

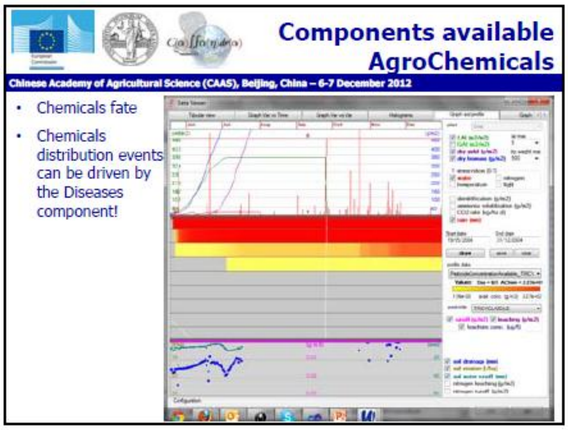

Components available
CropML
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
• WARM
• CropSyst
• WOFOST
• WOFOST GT
• WOFOST GT2
• STICS
• Canegro
• ...
Crop Model Library
CRA
Università di Milano
JRC IPSC, Agri4cast, Ispra, Italy

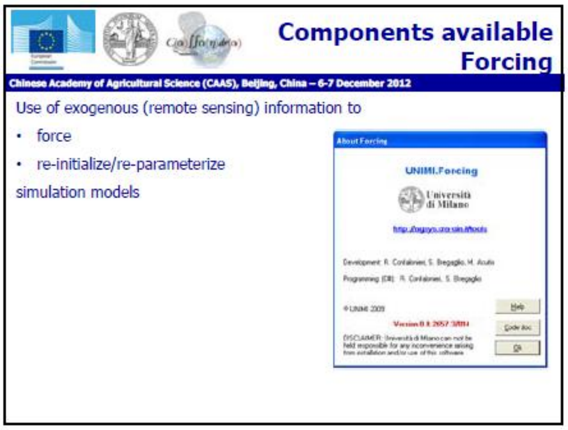

Components available
AbioticDamage
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
• frost
• temperature shocks
• salinity
• lodging
• ozone
AbioticDamage
CRA

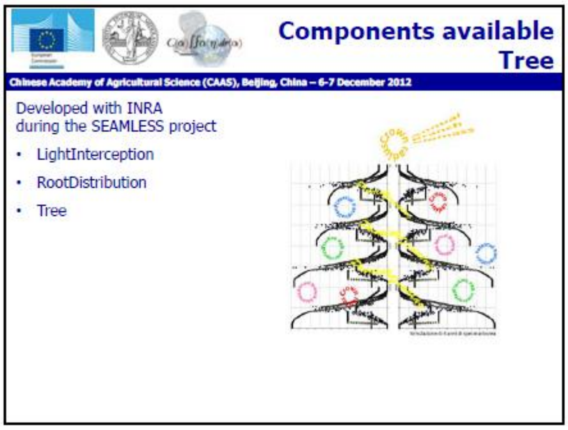

Components available
Hydrology
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
• SoilW
• SoilRE
• SoilT
Each implementing
• different approaches (Richards solver, cascading, travel-time)
• different implementations for the same approach
• hybrid solutions
• context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

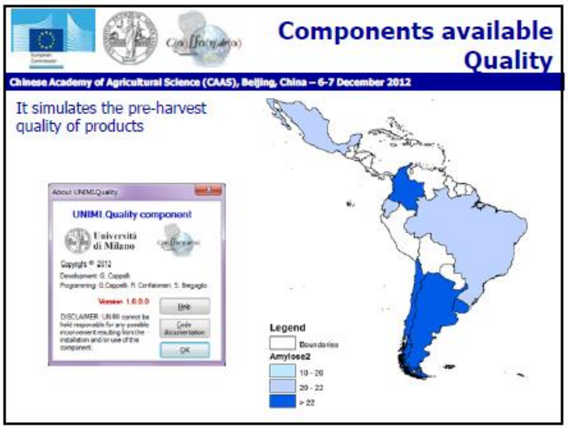

Components available
Pathogens
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
• Diseases
Risk of infection and damages, generic (suitable for each couple host plant-airborne pathogen)
• PotentialInfection
51 parameterizations available for different pathogens are available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

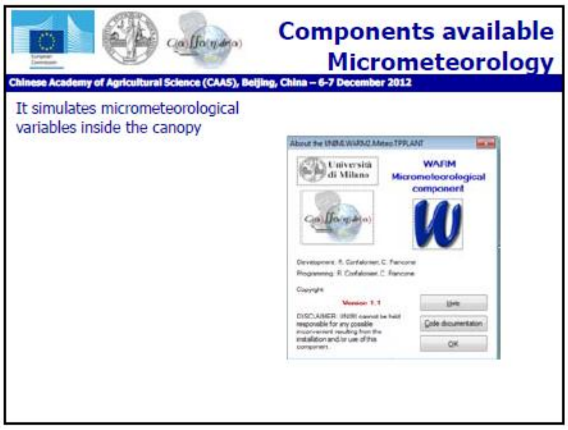

Components available
AgroManagement
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Generic component for agromanagement practices, based on the concepts of
• rule
• impact
It allows also the simulation of automatic practices with a high level of flexibility
CRA Agriculture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

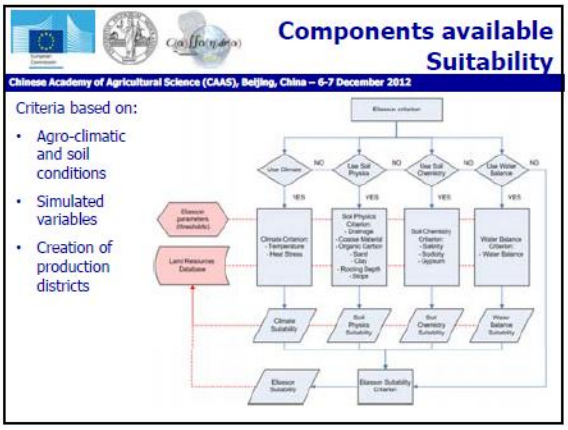

Components available
AgroChemicals
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Chemicals fate
Chemicals distribution events can be driven by the Diseases component!

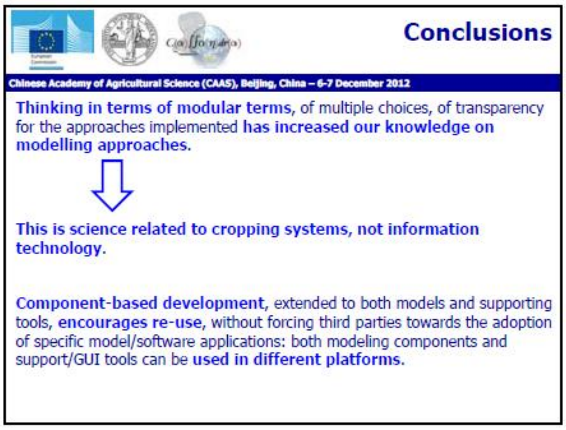

Components available
Forcing
Chinese Academy of Agricultural Science (CAAS), Beijing, China – 6-7 December 2012
Use of exogenous (remote sensing) information to
force
re-initialize/re-parameterize
simulation models
UNIMI.Forcing


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
Amylose2


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


European Commission
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")				