Coupling MAELIA and STICS: Toward New Opportunities for Agricultural Modelling Approaches

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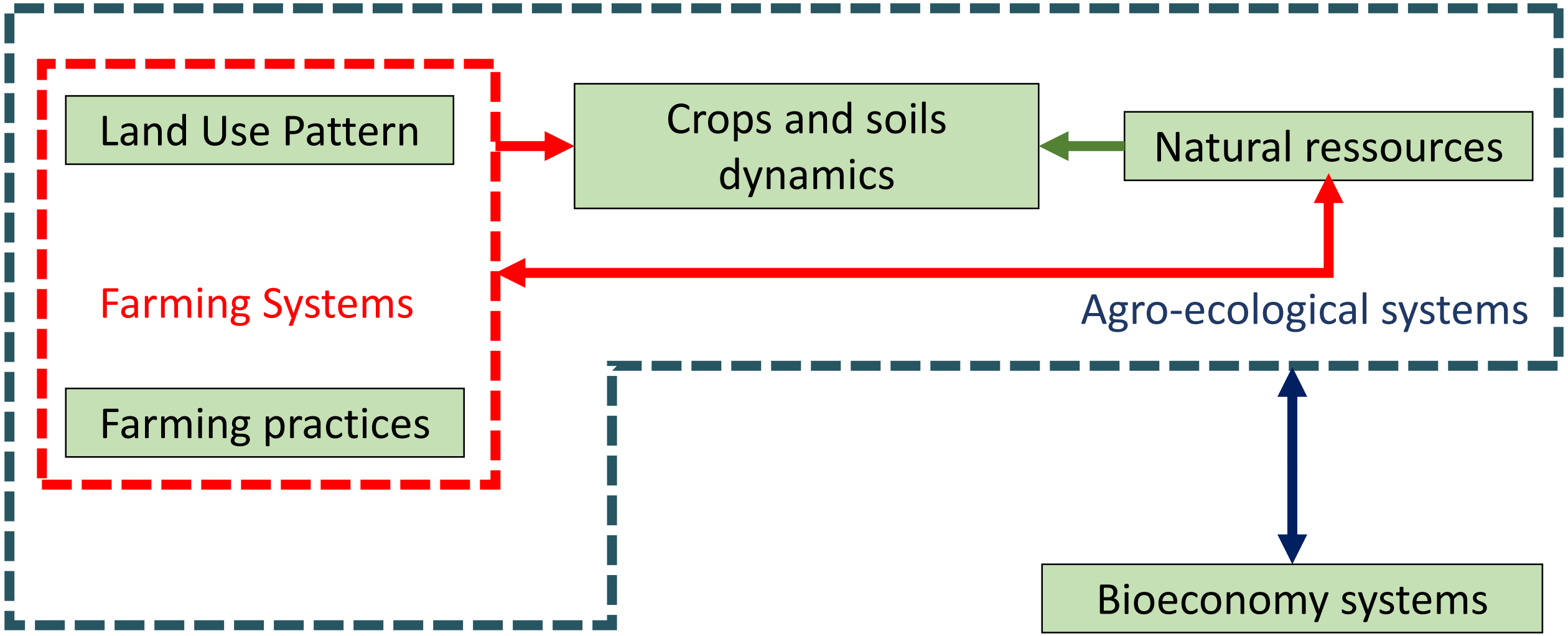
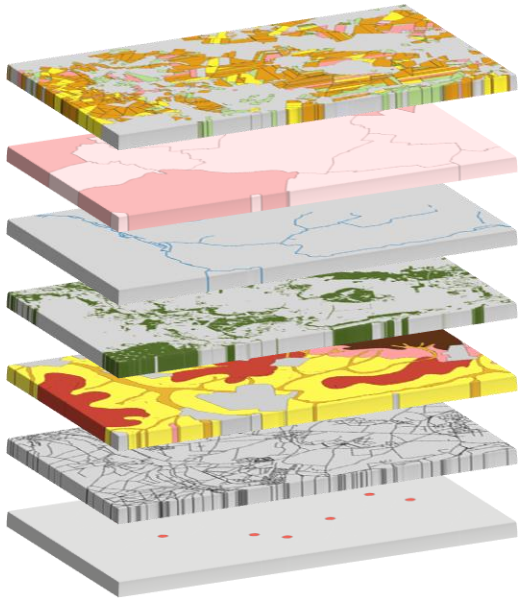
Introduction : how to model agricultural landscape ?



The MAELIA plateform

MAELIA

Georeferenced data-> Fine description of the landscape



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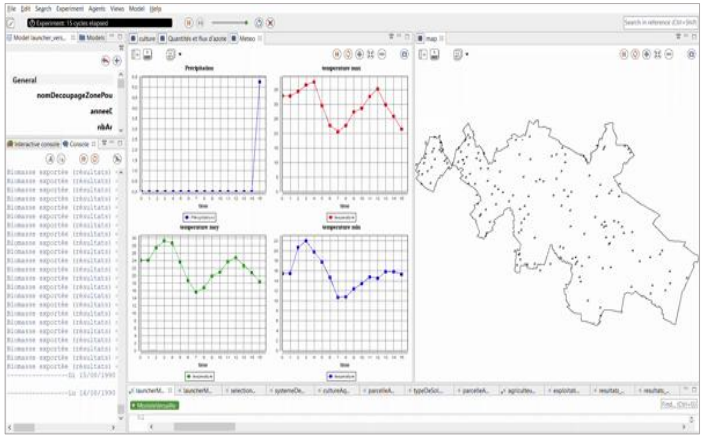
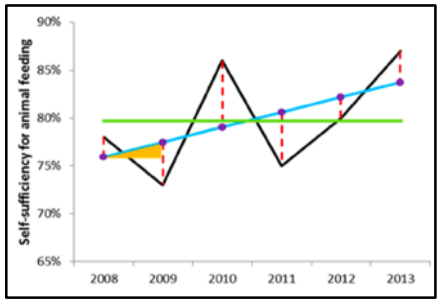
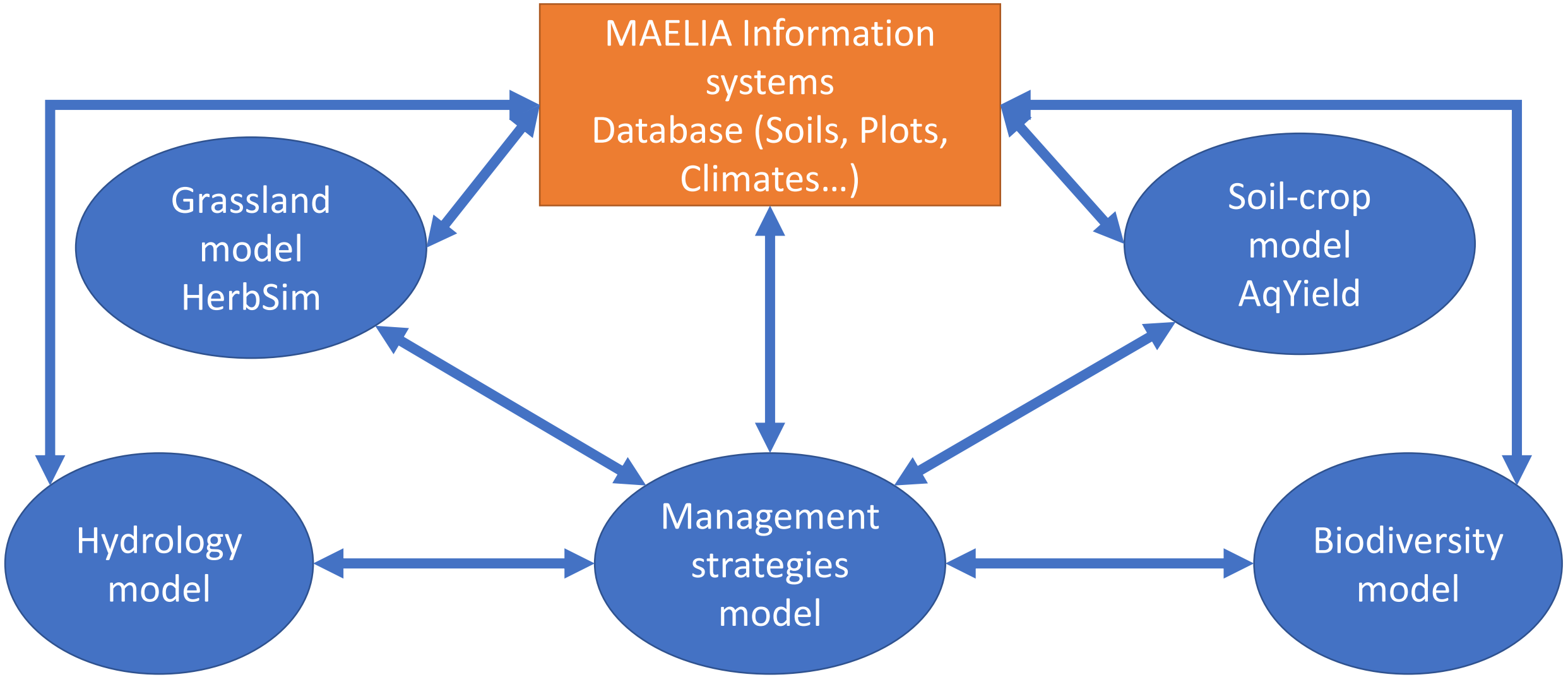
Model chain
Crops, Pastures, Farmers behaviour...



Evaluation – Indicators
Agronomic, Economic, Environmental
Sustainability & Resilience



The MAELIA plateform models



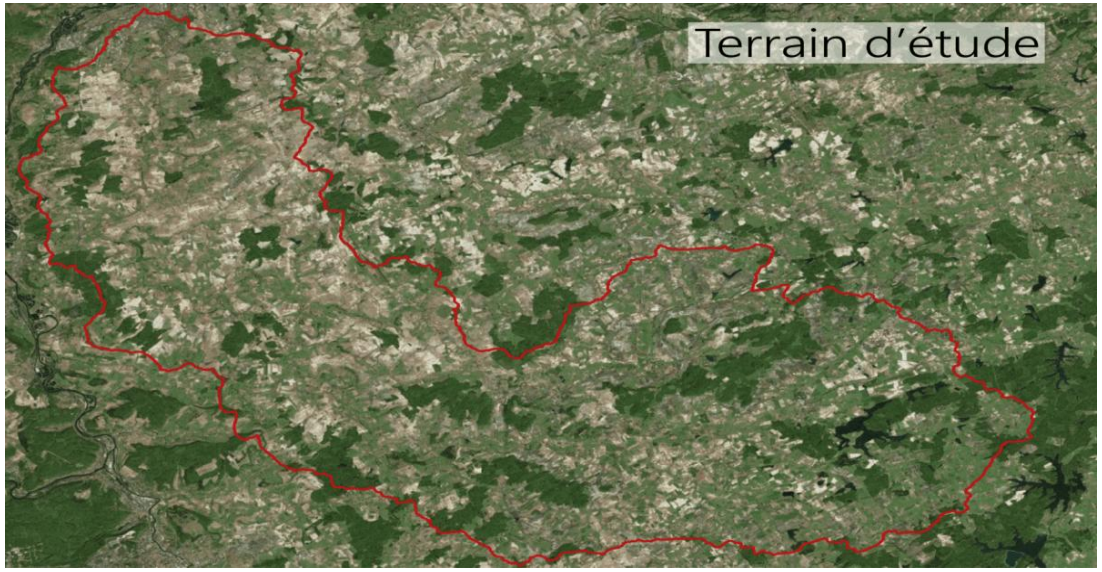
Why the MAELIA-STICS coupling ? A brief model comparison

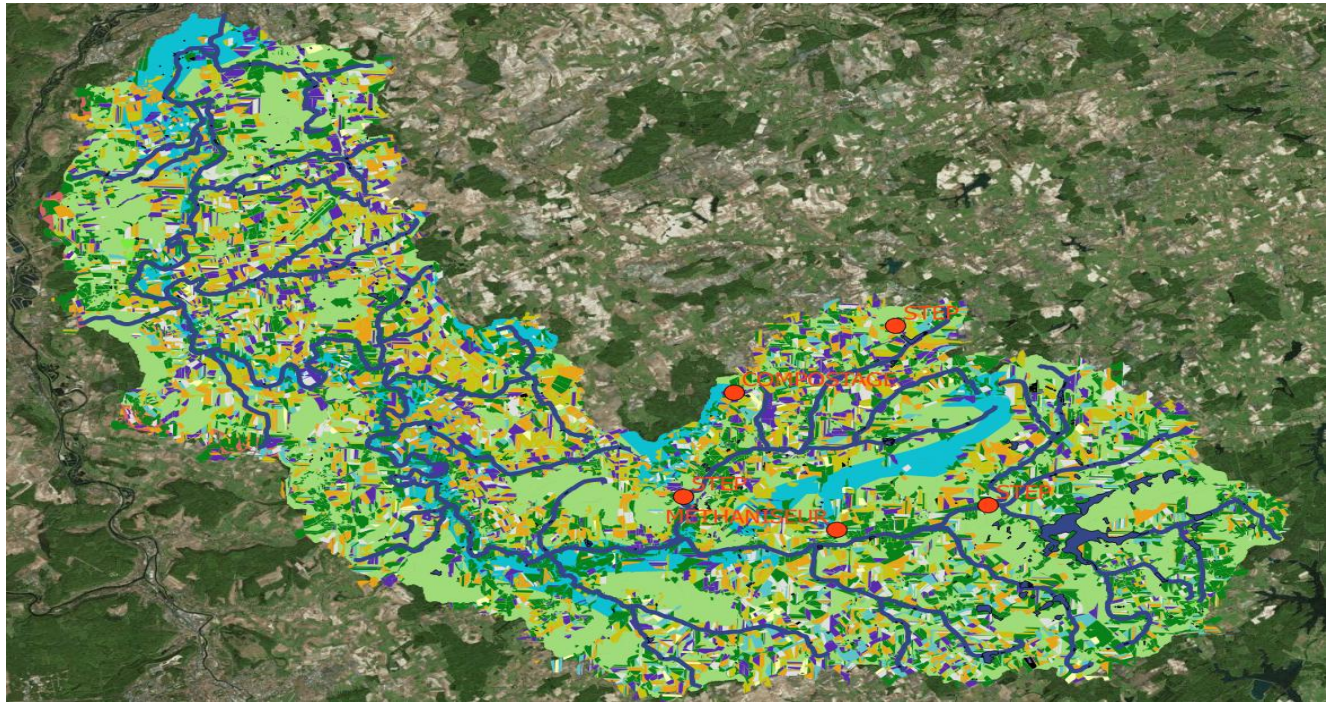
Aspect	MAELIA-AqYield	STICS
Spatial representation	Structurally explicit	Aspatial

MAELIA's representation of landscapes

Spatialized data

Climate
Agricultural practices
Crop rotations
Parcellaire agricole
Sols
Hydrographie





Final map : A clear representation of all real plots of a landscape with associated farms, weather, soil, crop succession and agricultural practices.

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Farm Level Representation	Plot linked to farmers (constraints of workload and equipment)	Not represented

The Decision Rule approach

Management strategy per crop and production situation : decision rules that triggers each operations.

Different management strategies can be defined depending on soils, previous crops, farm types….

Example for maize sowing

Between March 20th and May 31th

IF

Minimal temperature of the last 7 days > 3°C
AND Cumulated rainfall of the last 7 days < 10 mm
AND Available water capacity < 90%

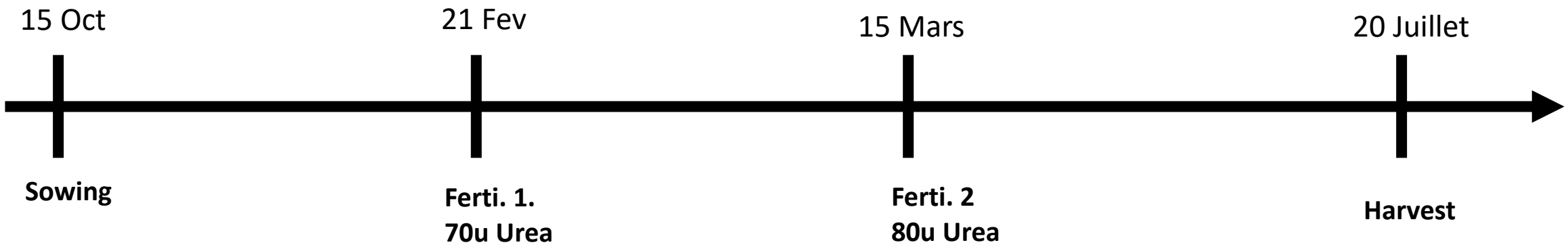
THEN I can sow

Decision rules (Linked to soil, climate, crop variable)

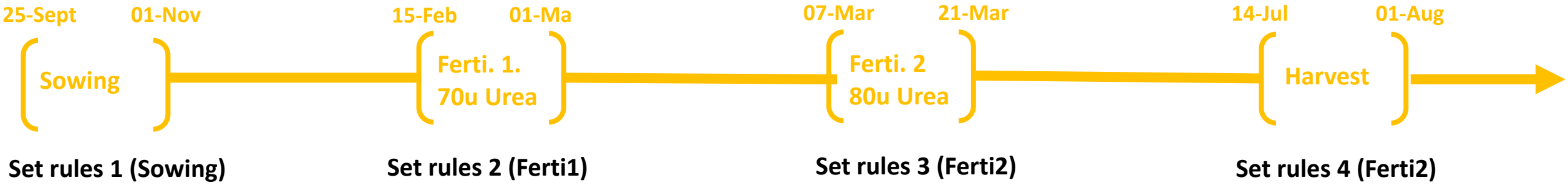
The triggering of the technical operation also depends on farms constraints (Ex: Workload)

Example : Technical operations for barley crop

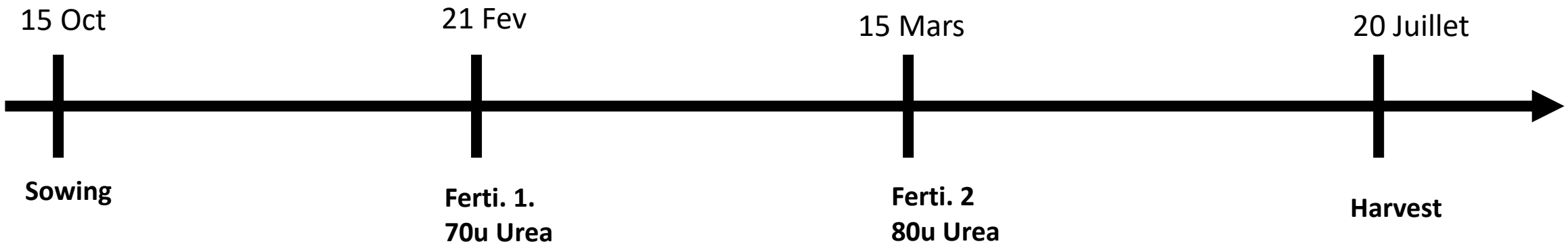
The DATE-DOSE approach



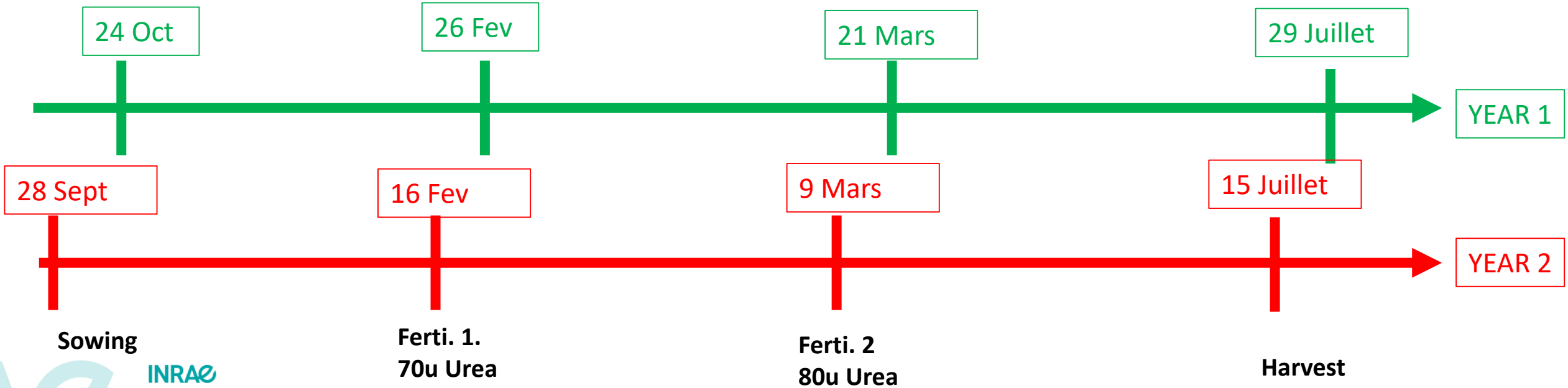
The Decision Rule approach



The DATE-DOSE approach : Fixed from year to year



The Decision Rule approach : Interyears variations



A brief model comparison

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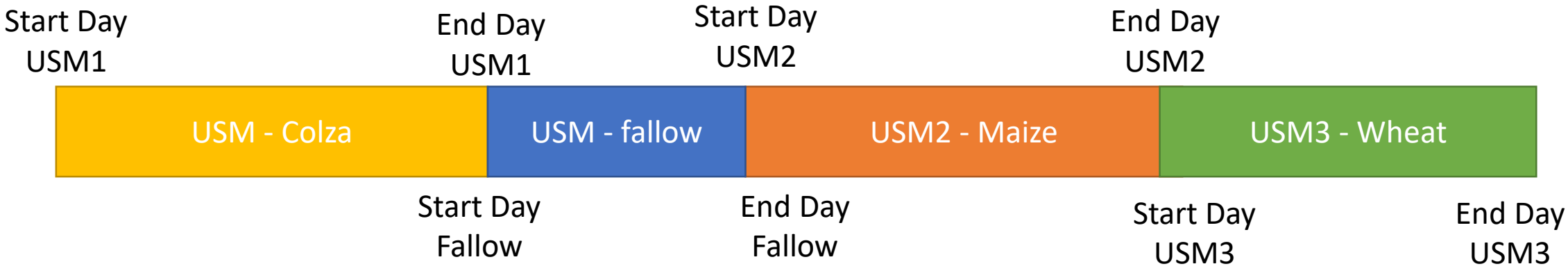
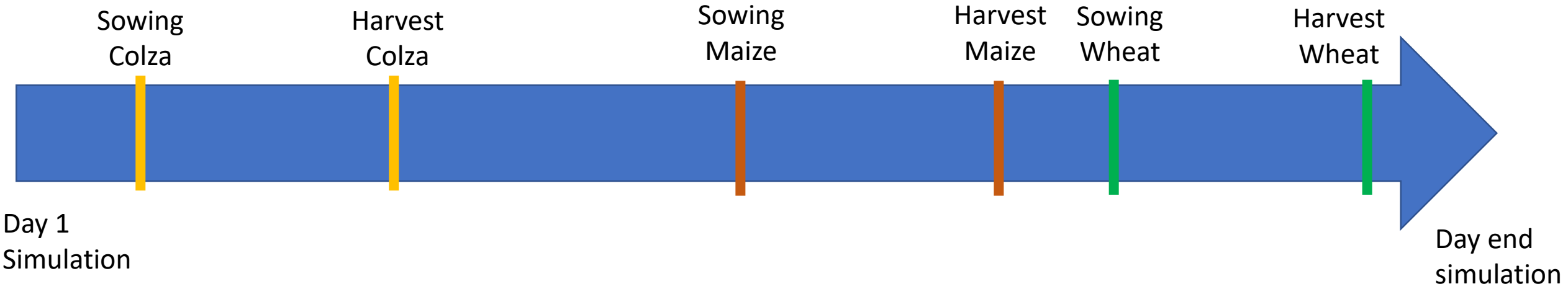
Technical Operations representation	Reflect the famers strategies (Decision rules approach)	Forced (Fixed Date-Dose)
Crop rotation dynamics	Continuous temporal	USMs succession

USMs succession approach



Continuous temporal



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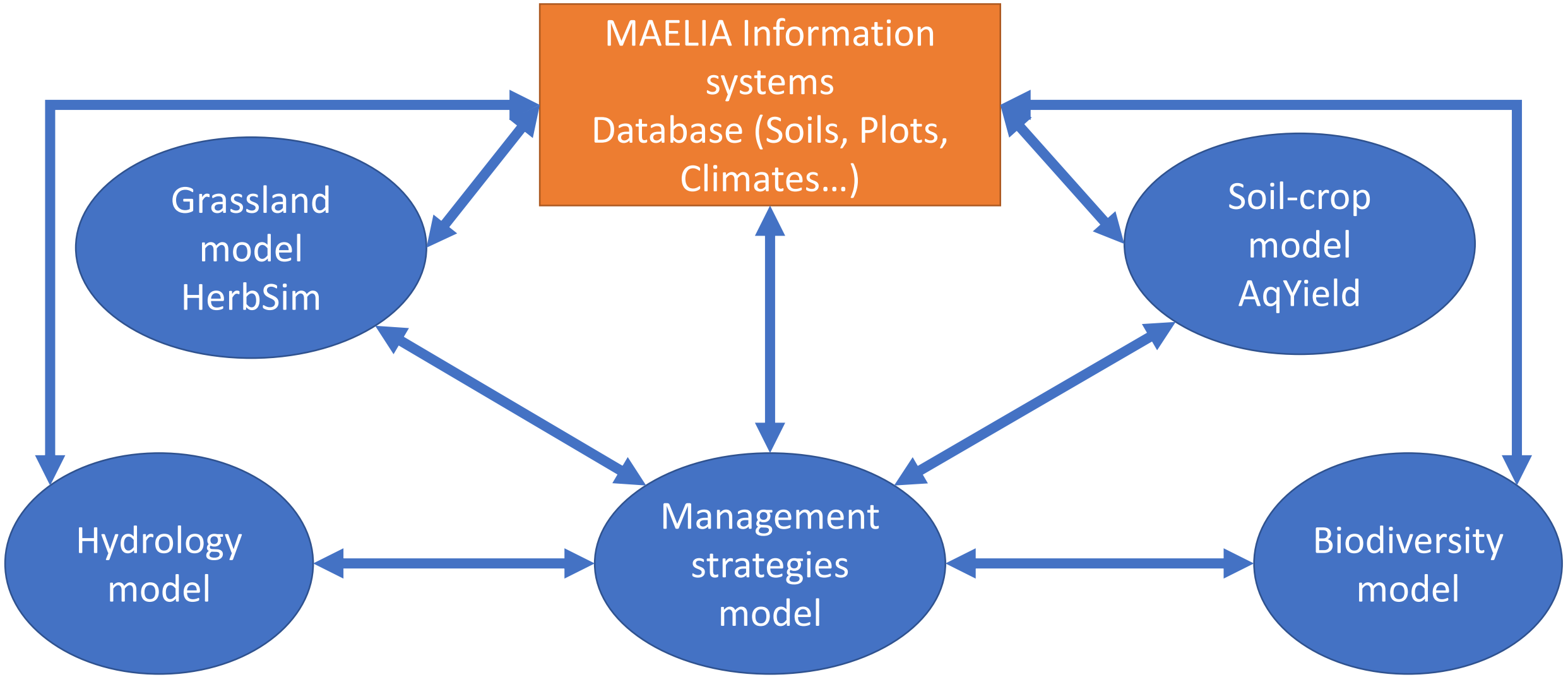
Crop Potential	Fixed, Input parameter	Estimated

Better in representing landscapes spatial structure and cropping systems

Better genericity, robustness, widely validated,and a more mechanistic representation of the soil-crop dynamics

A MAELIA-STICS coupled model, where MAELIA handles landscapes representation and cropping systems, and STICS handles soil-crop dynamics

The MAELIA plateform models



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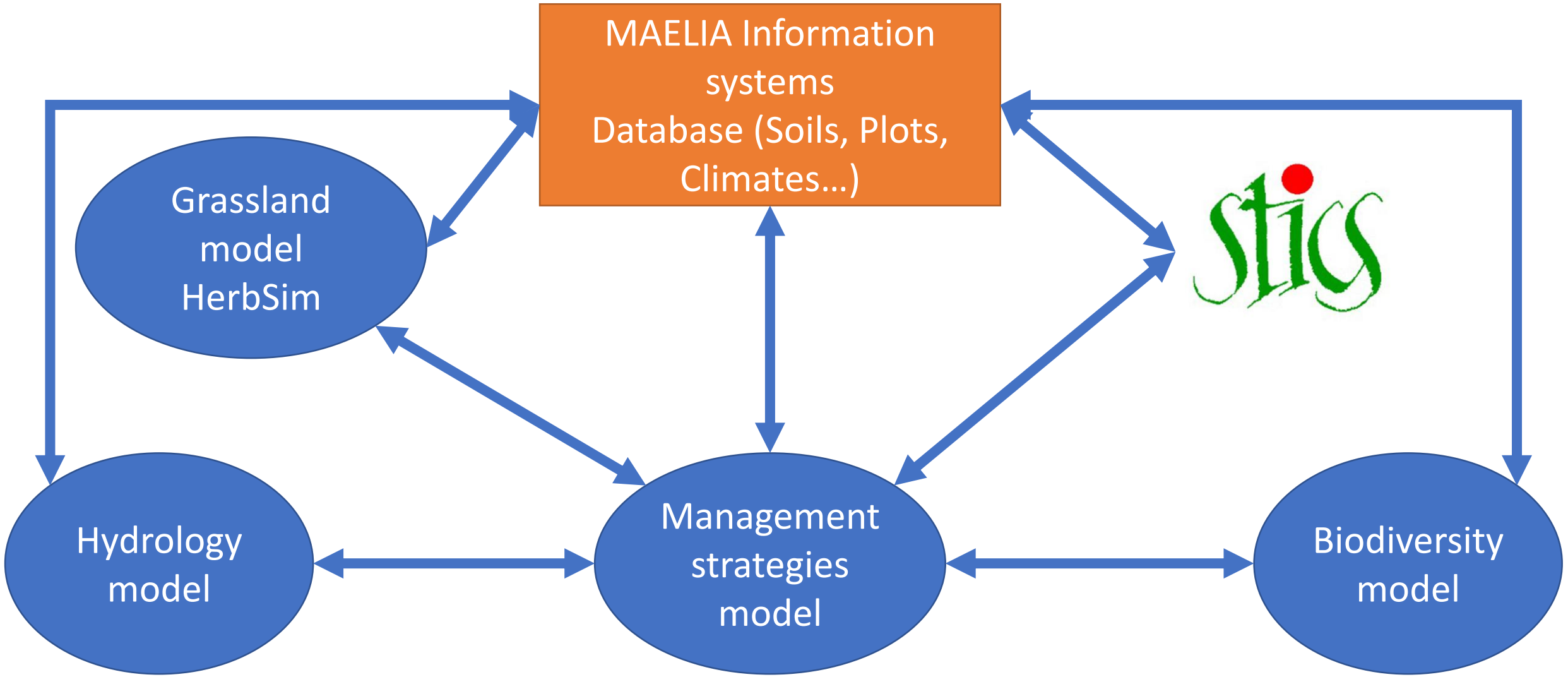
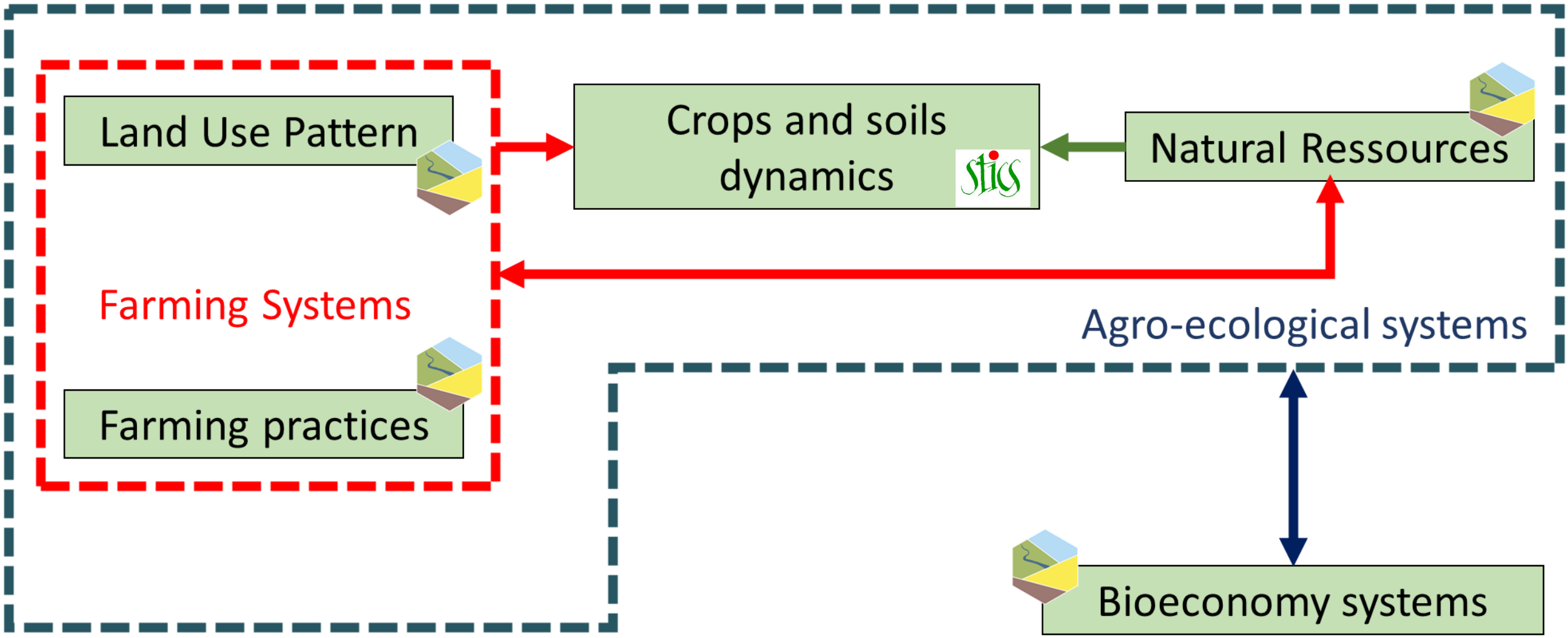
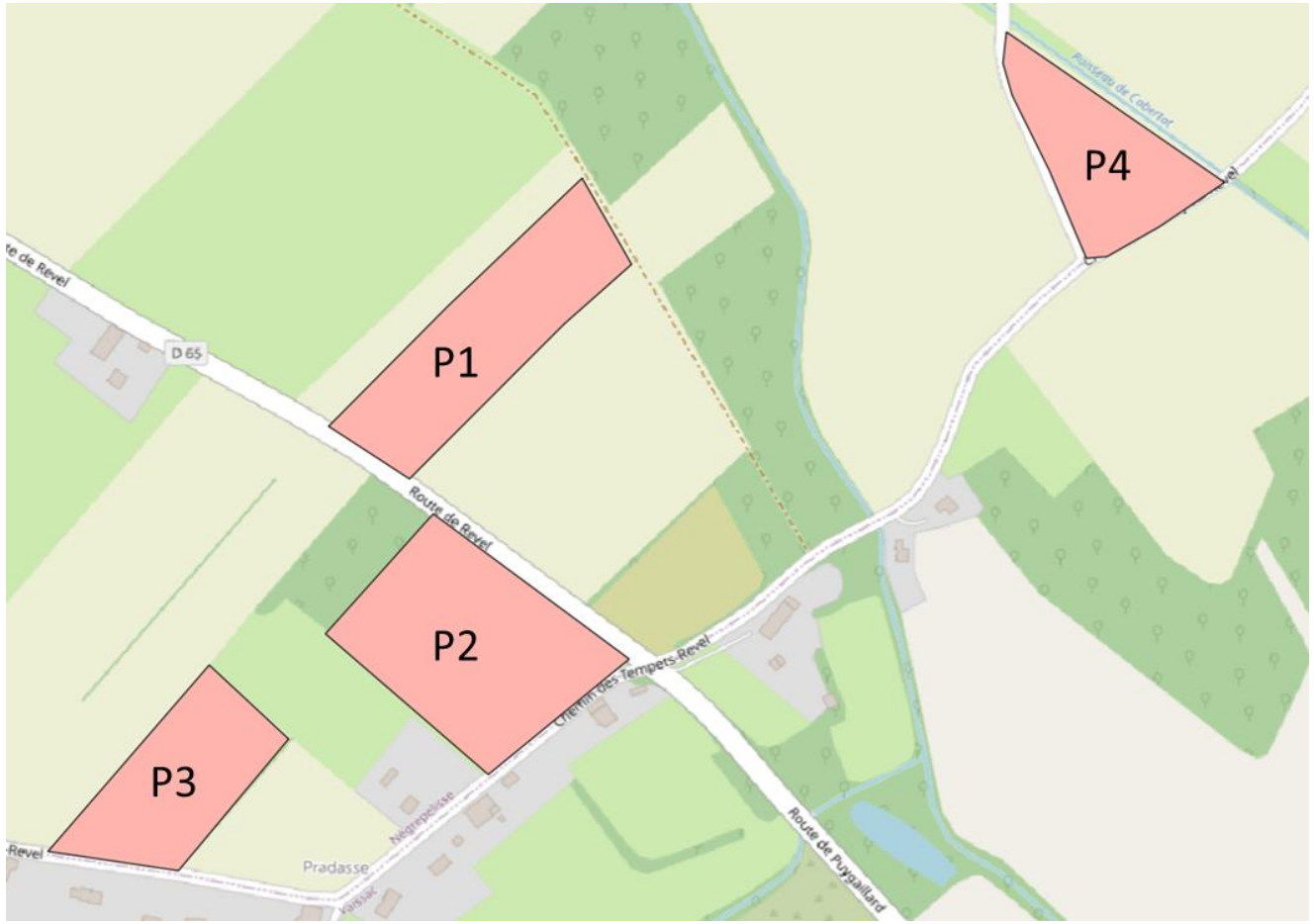


Agriculturals landscapes in the MAELIA-STICS approach



The MAELIA-STICS coupling : a simple example



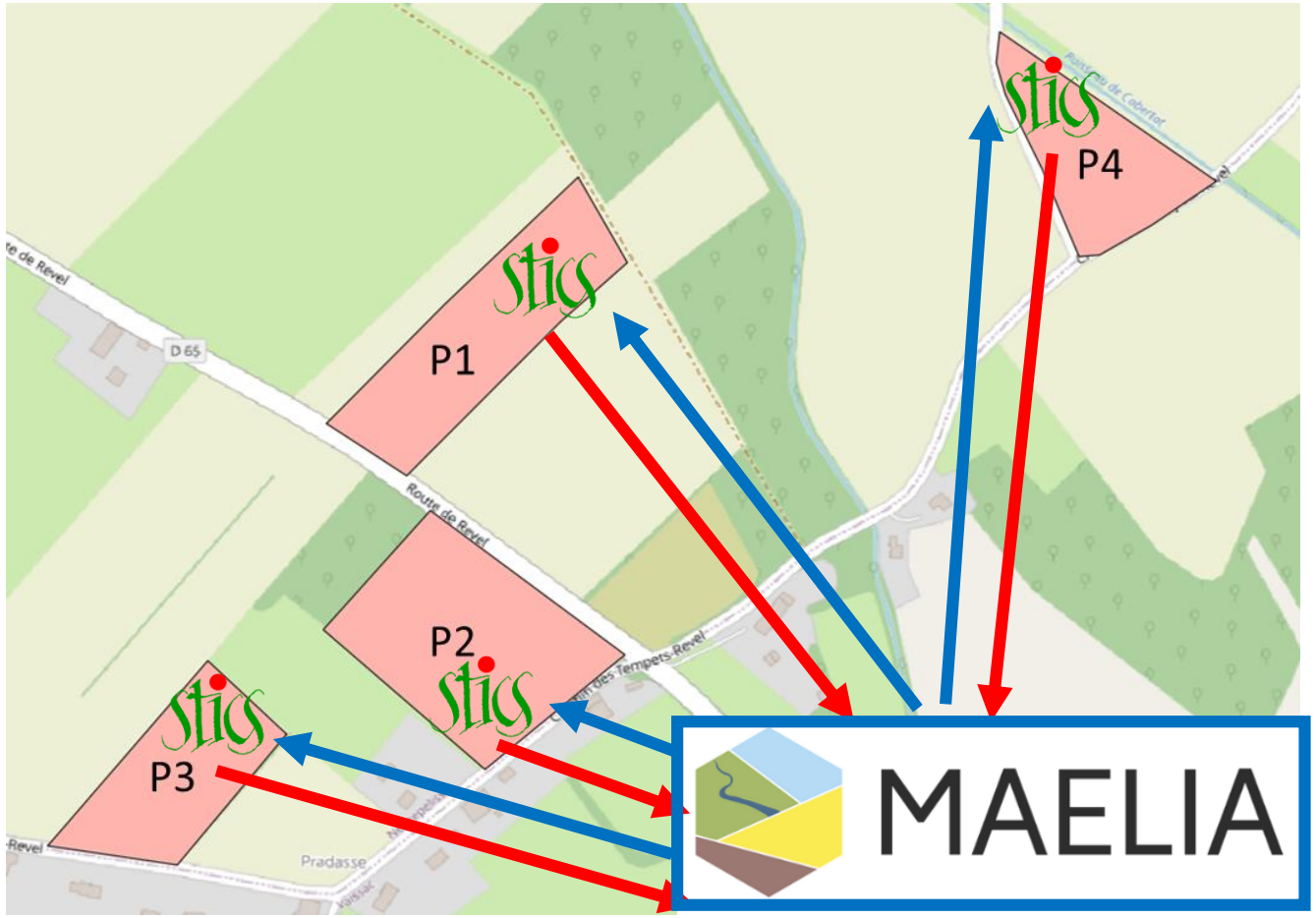
A farmer has 4 plots

Initialisation phase :

Each plots is linked to :

- a farmer
- a soil
- a climate
- a crop succession

The MAELIA-STICS daily loop



1) MAELIA calls STICS to simulate soil-crop dynamics for each plot

2) Key variables of soil-crop state are communicated to MAELIA

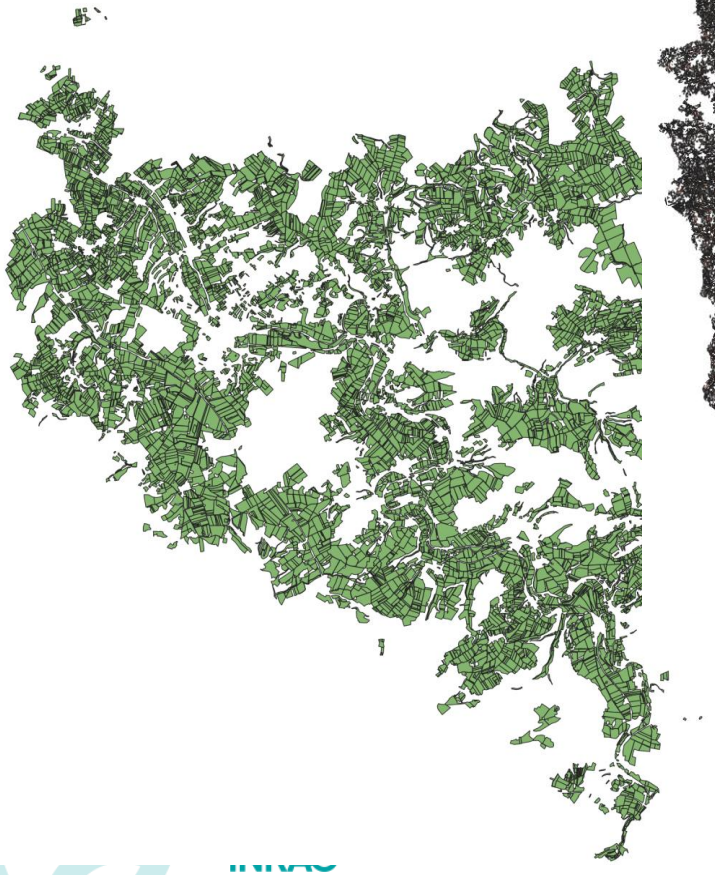
3) MAELIA perform other modules and read variables from STICS

4) If conditions to perform a technical operations are met, MAELIA triggers the technical operations

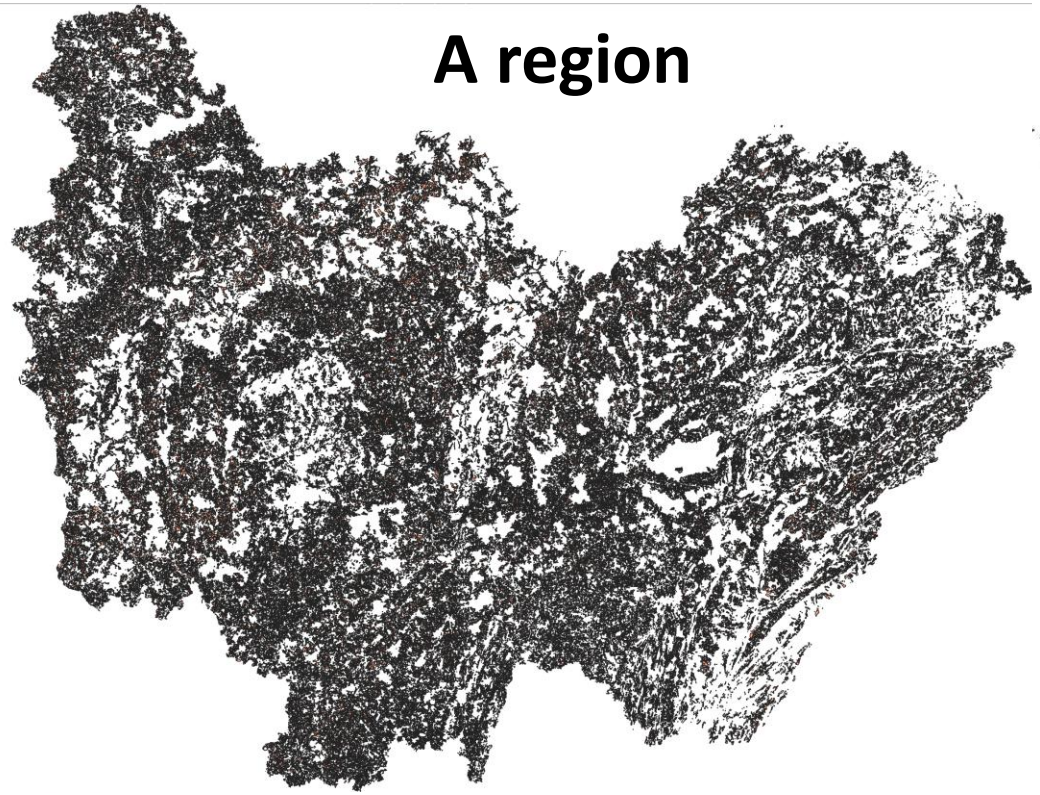
5) STICS simulates the technical operations when called on day+1 if available workload in the farm

Now imagine for :

A full landscape



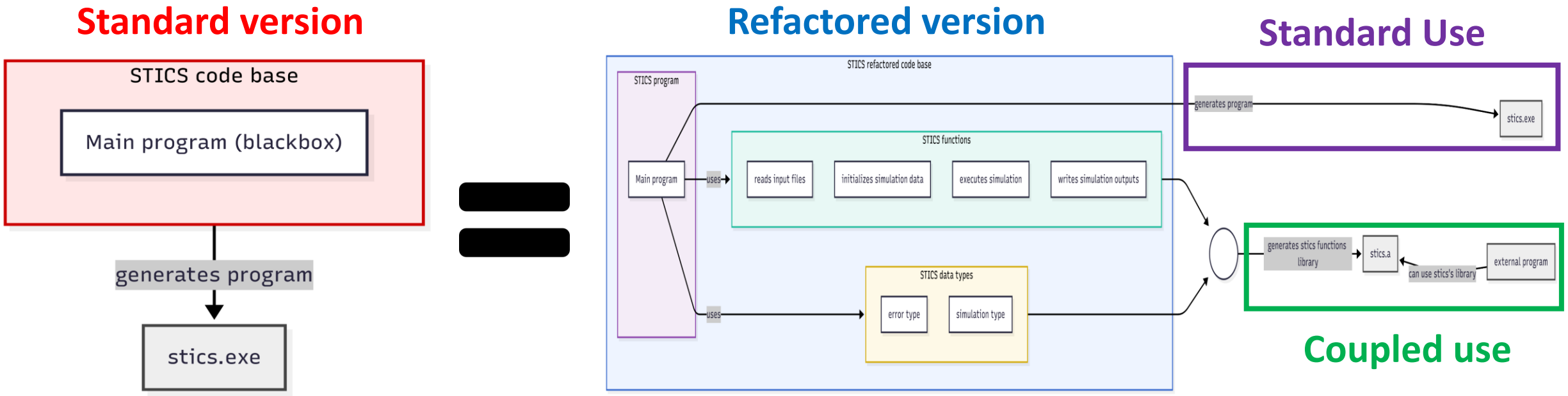
A region



A country

With thousands of plots and farmers and constrating pedoclimatic conditions and agricultural practices

How does it works ? : the minimal changes brought to STICS code



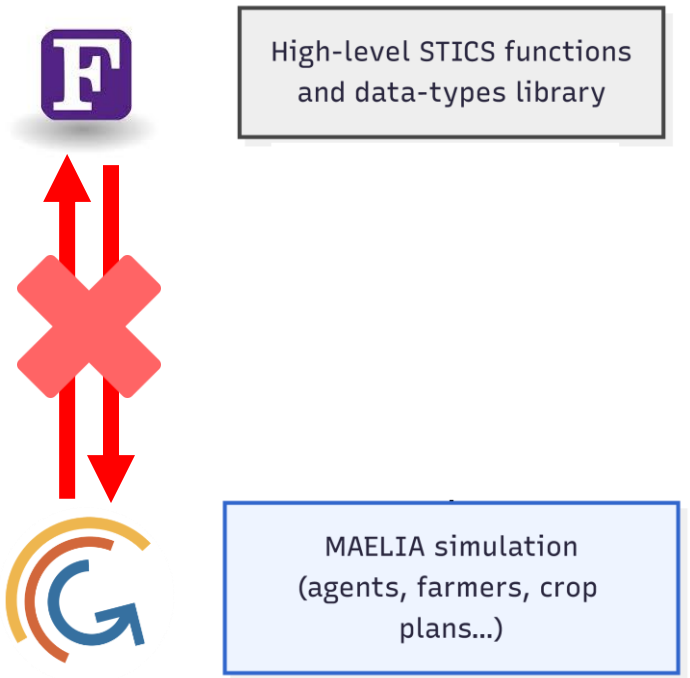
The internal code structure has been broken into smaller high-level independant functions. Produce both :

-> A program (stics.exe) for standard use

-> A library of fuction and data types for coupling with other models

Great granularity : Run USMs partially (day by day…), Read/write variables at any moment

How does it works ? : model communication



Pros:

- **Generic interface :** Other models can be used
- **Robust to code changes** in both STICS and MAELIA
- JSON protocol : **human readable and easy to understand**

Cons:

- **Performances could be less optimal** compared to more integrated coupling
- **Generic function integration only :** specific interactions requires additional specific functions

Expanding the capabilities for landscape assessment and simulating agroecological assessment: an hypothetical case study

The Tonnerrois Territory

~9000 plots, ~411 farmers ,Agricultural Area = ~41,000ha

Aim of the study :

- 1) Investigation the effect of climate change
- 2) Test different strategies of adaptation

Methods :

- 2 Simulation periods (2000-2020) and (2040-2060) with different climate projections

- Formalize different strategies and test them with the MAELIA-STICS models

Strengths of the MAELIA-STICS approach

Landscapes representations

- Realistic representation of landscape variability.
- Mechanistic and robust representation of crop and soil process
- Interyear variability of the cropping systems
- Wide range of crops representation (genericity)
- Embedded link with bioeconomic systems (biomass/food chain-value)

Climate change effect assesment

- Effect of the climate change on crop cycle duration, and technical operations date.
- Effect of climate change and new cropping cycle on potential and real yield.
- Embedded link with hydrological systems

Capacity to test scenarios

- Easy implementation of scenarios due to the continuous temporal simulation
- Higher capacity to represent new cropping systems including intercropping
- Large range indicators for evaluation at the plot and landscape scale

Conclusions

- MAELIA-STICS combine best assets of both STICS and MAELIA
- Higher capabilities for landscape simulation in term of representation, assessment and scenarisation
- Highly Generic, non-distrubtive coupling approach, reusable for different models
- Coupling almost complete, first case study currently under construction

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Thank you for your attention

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