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AGRICULTURAL RESEARCH FOR DEVELOPMENT

Working together for tomorrow's agriculture

Some example of CIRAD’s experience and prospects in digital agriculture in Brazil

Sarah Valentin CIRAD/TETIS

Joannès Guillemot CIRAD/Eco&Sol

Krishna Naudin CIRAD/AÏDA

CIRAD is the French agricultural research and international cooperation organization working for the sustainable development of tropical and Mediterranean regions.

Human resources

1800
employees, **with**

1240
scientists, including

800
researchers or PhD students

Annual budget

€ 240M
Public service subsidy

60%
Contractual resources

40%

Scientific publications

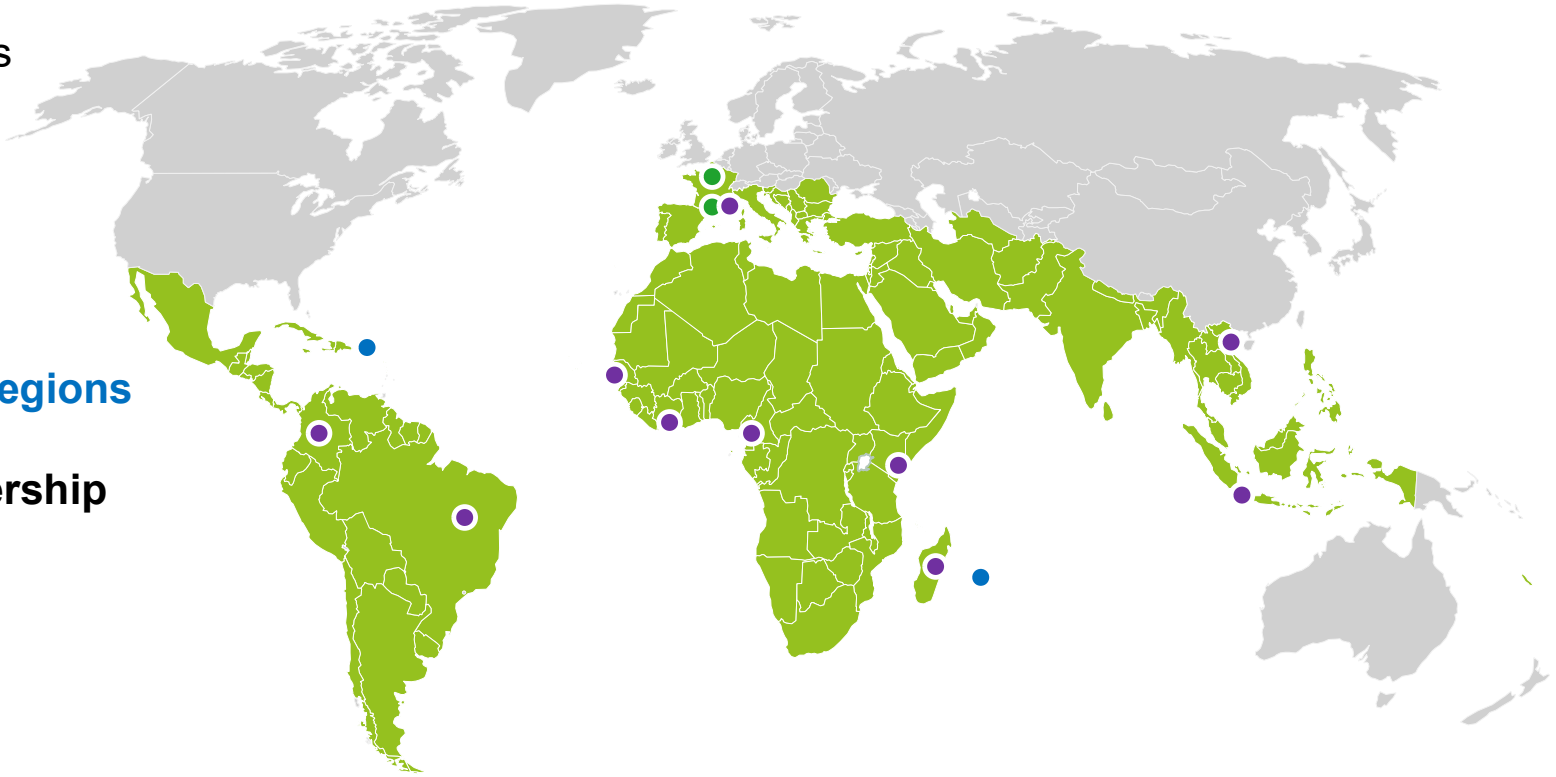
1200
articles in peer-reviewed journals, books and book chapters
including

600
co-published with partners from the global South

CIRAD worldwide

- CIRAD works in more than **50 countries** across the tropics and the Mediterranean.

- From its regional offices, **two in mainland France**, **two in the French overseas regions** and **ten elsewhere**, it conducts **research in partnership** with more than 100 countries.



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Three scientific departments

Biological Systems (BIOS)

- The living world, its characterization and its exploitation
- Nine research units

Performance of Tropical Production and Processing Systems (PERSYST)

- Tropical production operations, from plot to product processing
- Ten research units

AIDA

Agroecology and sustainable intensification of annual crops

Interactions between soil organism and plant, biogeochemical cycles - mainly C, N and P cycles

ECO & SOLS

Environments and Societies (ES)

- The relations between agriculture, natural resource management and social dynamics
- Ten research units

tetis
TERRITOIRE ENVIRONNEMENT TÉLÉDÉTECTION INFORMATION SPATIALE

Spatial information to understand territorial complexity, agro-ecosystems and support for stakeholders

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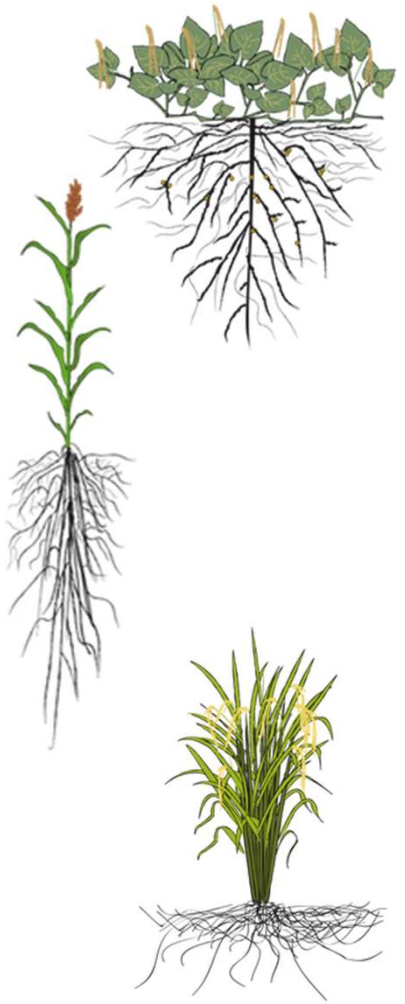
AIDA works on **ecological intensification** of **cropping systems** based on **annual crops** in **tropical family farms**



Analyze and design cropping systems based on annual crops, making better use of resources and ecological processes, by assessing their agronomic, environmental, economic and social performance in different spatial and temporal dimensions.

Intensify and stabilize production in different types of tropical family farming agrosystems based on :

- rainfed and flooded **rice** - Asia, Madagascar
- **cotton** - Africa
- dry cereals (**corn, sorghum, millet**) in dry to sub-humid zones - Africa, Latin America, Asia
- **sugar cane** - Reunion, West Indies, Africa
- **pulses** (cowpea, soybean, pigeon pea) - Africa, Asia
- **roots and tubers** (Cassava) - Africa, Asia, Latin America

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Agroecology and sustainable intensification of annual cropping system

89 employee,
58 scientists,
22 à abroad,
24 in French oversea territory, 43 inland France
Involved in the supervision of 45 PhD students

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in Brasil , past and present

Alternative to slash and burn
Cassava cropping system
8 years

UFRA

Embrapa

Agroecology and water management
3 years

CEARÁ GOVERNO DO ESTADO FUNCEME

Modeling adaptation to climate variability, CHG emission, C sesquestration
30 years

Embrapa

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3 examples of the of advanced computational capacities in agronomy

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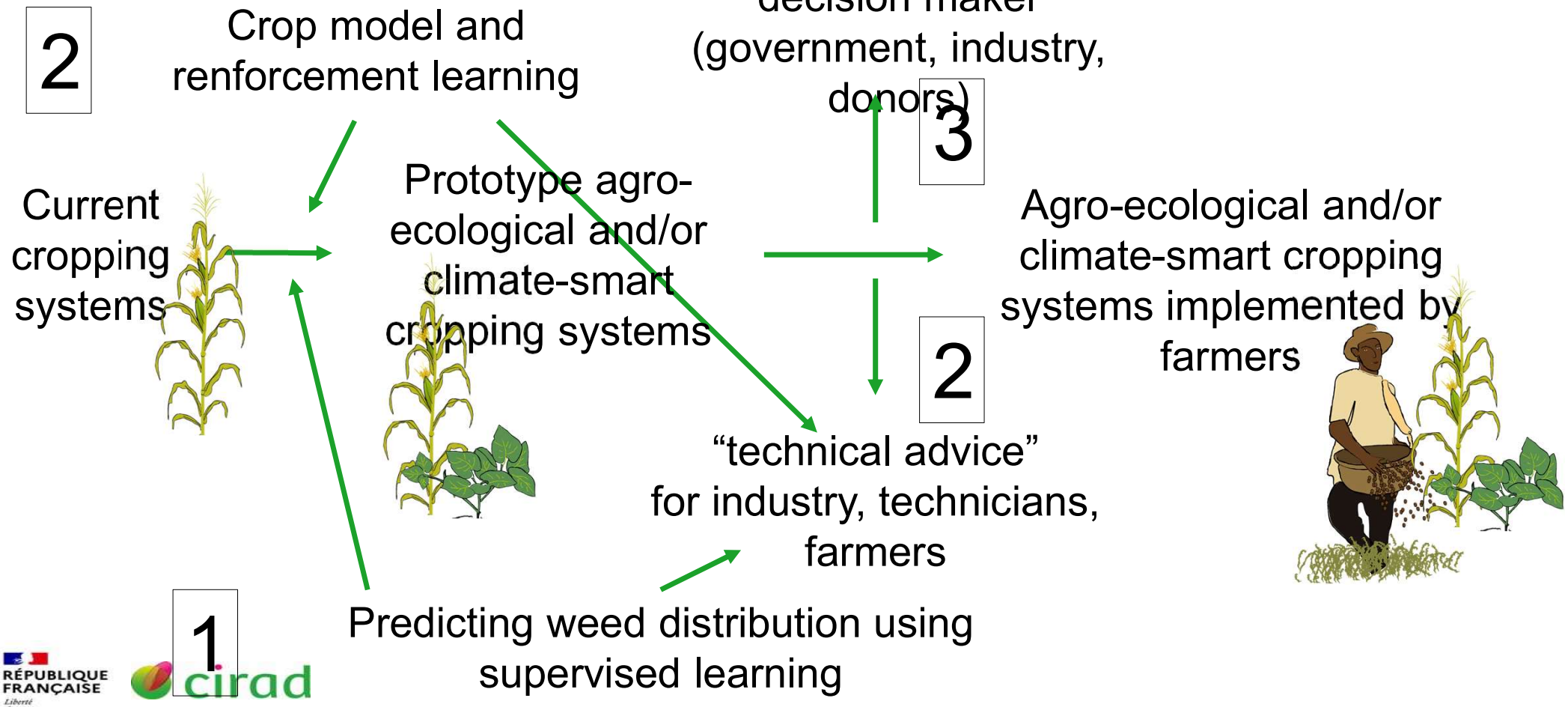
2
Crop model and renforcement learning
Informations for “tactical” decision for decision maker (government, industry, donors)
3
Current cropping systems
Prototype agro-ecological and/or climate-smart cropping systems
Agro-ecological and/or climate-smart cropping systems implemented by farmers
2
“technical advice” for industry, technicians, farmers
1
Predicting weed distribution using supervised learning

Informations for
“tactical” decision for
decision maker
(government, industry,
donors)

Current
cropping
systems

Prototype agro-
ecological and/or
climate-smart
cropping systems

Agro-ecological and/or
climate-smart cropping
systems implemented by
farmers

“technical advice”
for industry, technicians,
farmers

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Informations for
“tactical” decision for
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Predicting weed distribution using
supervised learning

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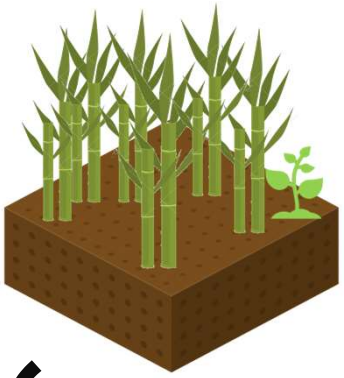
1

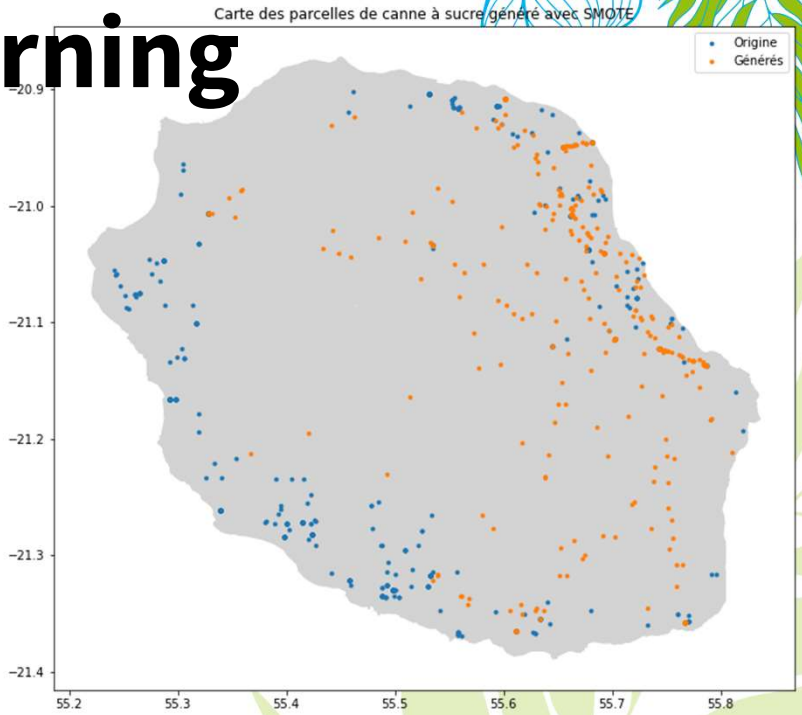
Predicting weed distribution using supervised learning



Euphorbia heterophylla L.

Commelina Benghalensis L.

Cynodon dactylon (L.) Pers.



Altitude
Average temperature
Rainfall
Location
Radiation
Season

- First results but limitations in the use of algorithms

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PhD Fabre-Ferber

Pistes de recherches

01

Manque de variables

Comment on construit de nouvelles variables informatives

02

Algorithmes pas adaptés

Adapter les algorithmes actuels à ce genre de données (Fabre Ferber et al., 2024)

03

Manque de données

Comment générer de nouvelles données augmentant la base de conaissance

04

Valeurs manquantes

Comment combler les valeurs manquantes (continues ou catégorielles)

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2

Crop model and renforcement learning

Current cropping systems

Prototype agro-ecological and/or climate-smart cropping systems

“technical advice” for industry, technicians, farmers

Agro-ecological and/or climate-smart cropping systems implemented by farmers

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Crop model and Reinforcement Learning environment

•An agent interacts with an unknown and uncertain environment by taking actions to control its evolution.
•A policy defines the agent's decision rules based on observations from the environment.
•The agent's actions affect the environment, and it receives a return, a scalar value indicating its performance.
•The agent aims to maximize a utility function through trial and error, adjusting its policy based on the returns received.

Works great if you're just trying to sell more stuff online, but it's a whole different game when you're dealing with farming systems—especially when it comes to agroecological systems!

Solution: train the reinforcement algorithm on a crop model that allows for virtually testing millions of combinations before moving to the real world.

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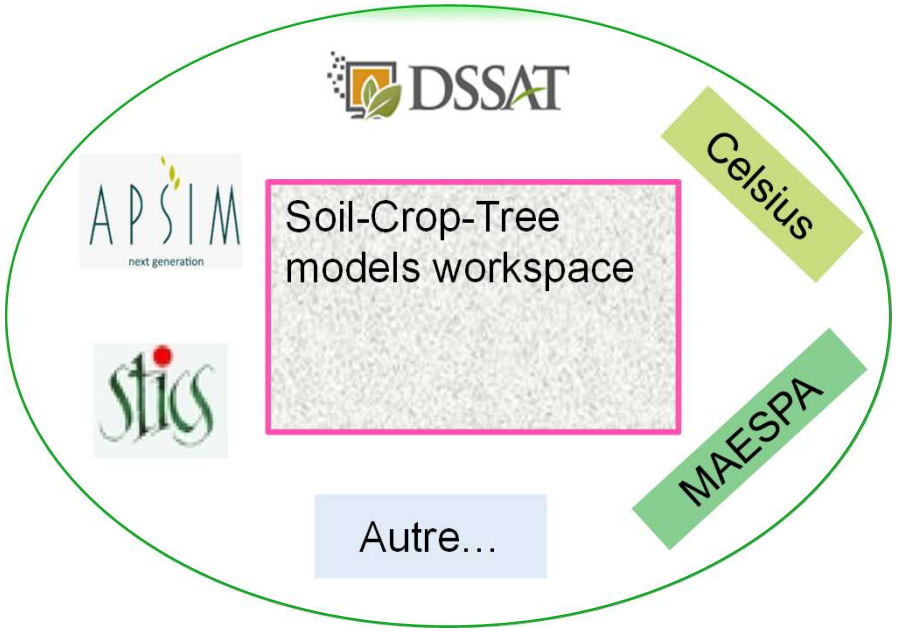
Some promising results and experiments, but we're still in the early stages



Inria

gym-DSSAT: a crop model turned into a Reinforcement Learning environment

Romain Gautron*, Emilio J. Padrón†, Philippe Preux‡, Julien Bigot§, Odalric-Ambrym Maillard¶, David Emukpere‖

?

Contents lists available at ScienceDirect

Computers and Electronics in Agriculture

journal homepage: www.elsevier.com/locate/compag

Review

Reinforcement learning for crop management support: Review, prospects and challenges

Romain Gautron [a,b,c,*], Odalric-Ambrym Maillard [d], Philippe Preux [d], Marc Corbeels [a,b,e], Régis Sabbadin [f]

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cirad AIDA Inria Alliance Bioversity & CIAT MIA TOULOUSE CRIStAL Centre de Recherche en Informatique, Signal et Automatique de Lille

3

Informations for “tactical” decision for decision maker (government, industry, donors)

Current cropping systems

Prototype agro-ecological and/or climate-smart cropping systems

Agro-ecological and/or climate-smart cropping systems implemented by farmers

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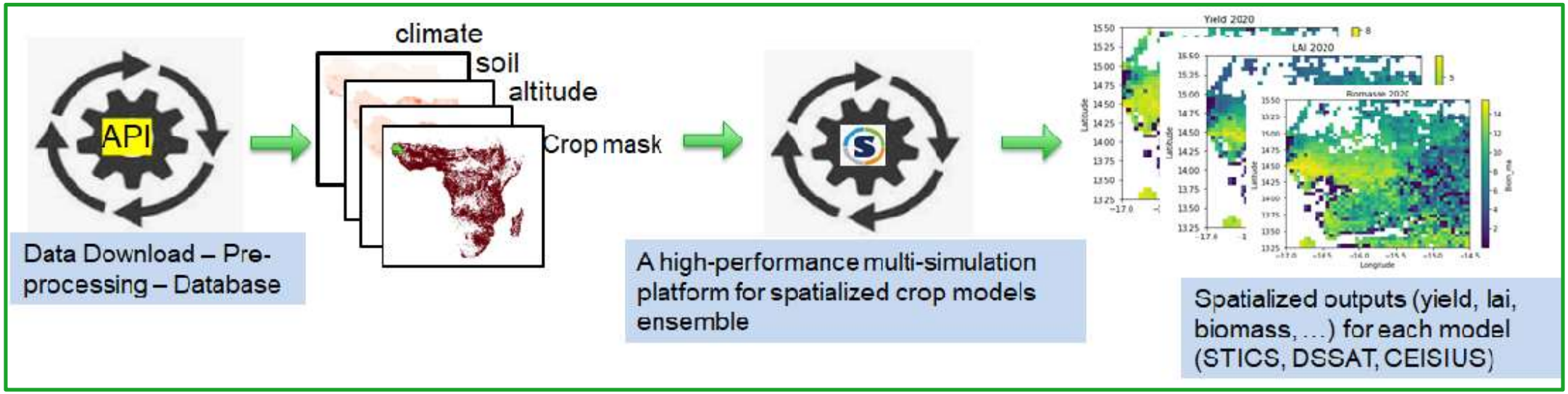
3

High –performance multi-simulation for spatialized crop model



Data Download – Pre-processing – Database

A high-performance multi-simulation platform for spatialized crop models ensemble

Spatialized outputs (yield, lai, biomass, …) for each model (STICS, DSSAT, CEISIUS)

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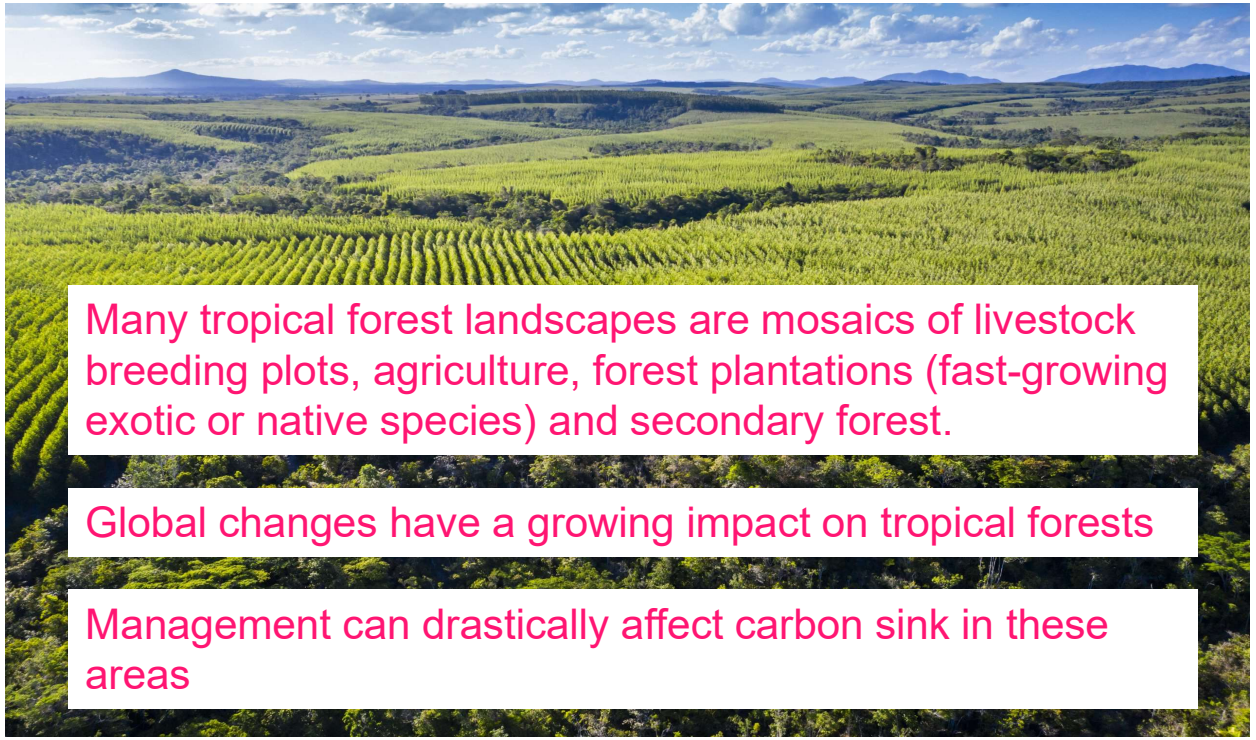
Ecosystem services in anthropized tropical forest landscapes

Joannès Guillemot, Guerric le Maire, Ivan Cornut, Agnès Robin, Daniel Mika-Nsimbi Poultney, et al.



Many tropical forest landscapes are mosaics of livestock breeding plots, agriculture, forest plantations (fast-growing exotic or native species) and secondary forest.

Global changes have a growing impact on tropical forests

Management can drastically affect carbon sink in these areas

Joannes.guillemot@cirad.fr
Cirad – UMR Eco&Sols

A long-term partnership with ESALQ (>20 years)

- At least one researcher from CIRAD Eco&Sols has been based at USP-ESALQ for the past 20 years (as a visiting professor in the forest science and soil science departments)

- Projects funded by Brazil (FAPESP, CAPES, …) or France (ANR, European projects, …)

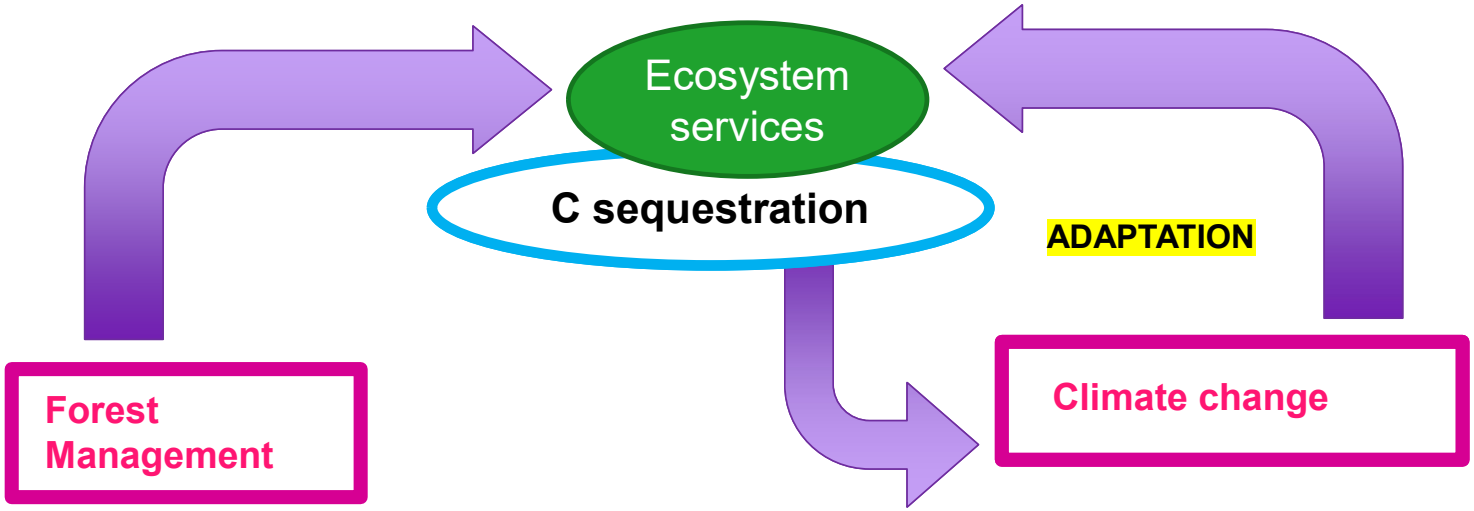
- Many Master and PhD thesis students co-supervised

- Hundreds of articles published

Scientific cooperation agreement renewed in 2023

Scientific objectives

Improving our understanding of the determinants of carbon, water and nutrient cycles in planted tropical forests to improve management practices under climate change



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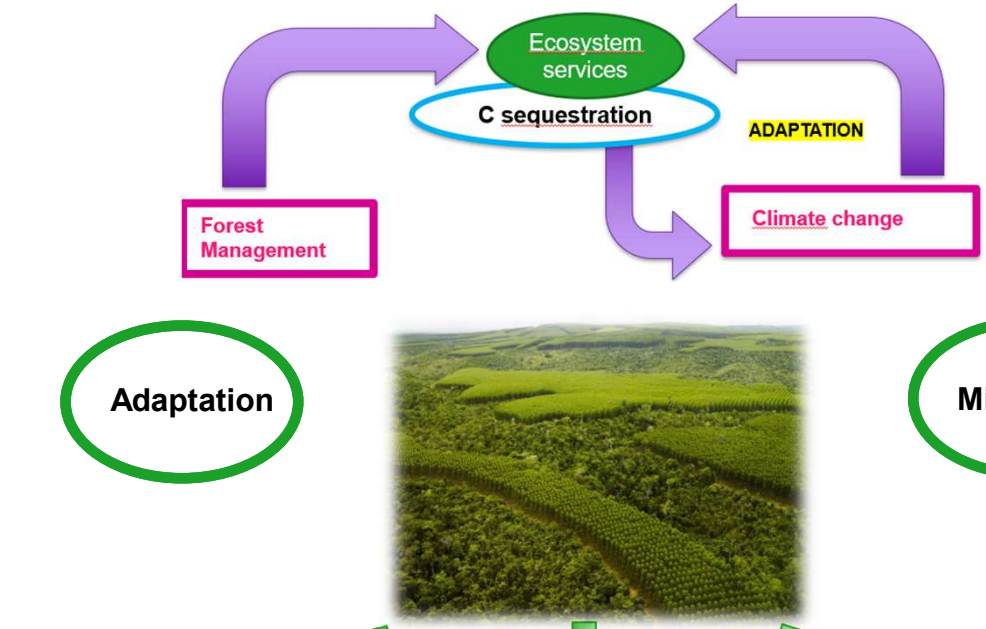
Scientific objectives



Forest restoration
Recover all or part of the ES provided by the original forest

Eucalyptus plantation
Limiting the ecological impact of high-growth monocultures

Native species plantations
Produce sustainable wood from indigenous species and relieve pressure on primary forests

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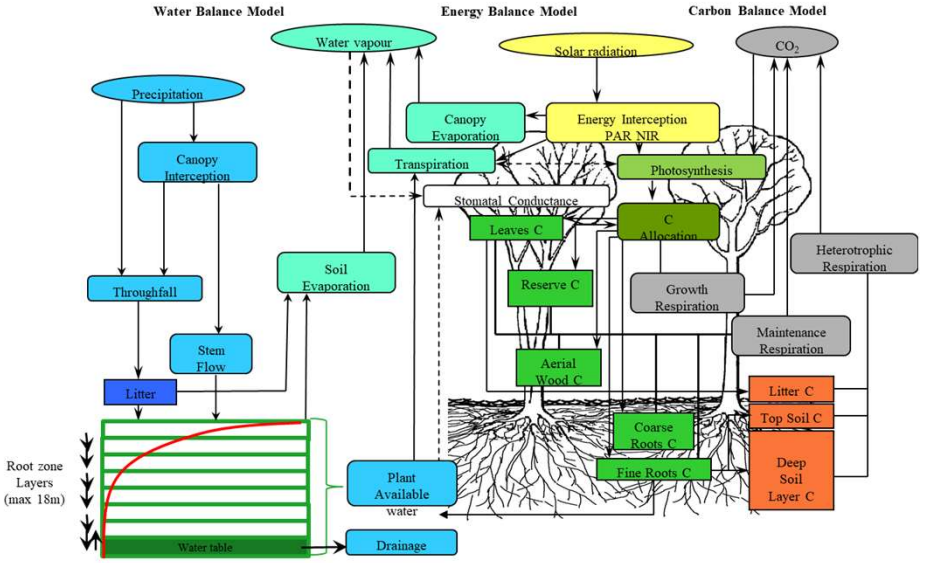
Development,
Parameterization,
Validation

High-precision measurements of water and carbon flows and stocks, biomass, radiation, microclimate.(Eucflux + other experiments)

Modeling at the tree or plot scale, process-based modeling: Quantitative simulation of flow and stocks of C, H2O, etc.

Understanding,
Focusing



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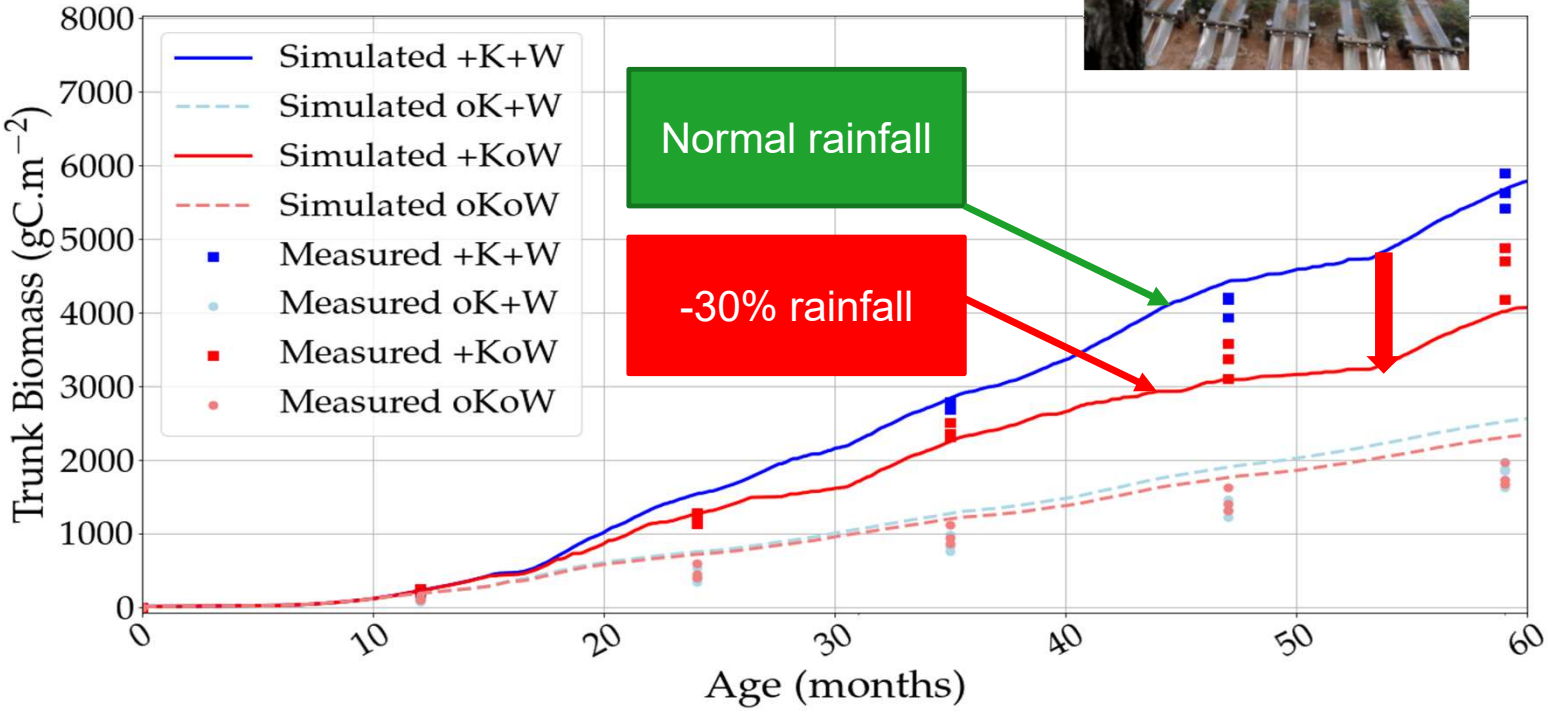
Model test for rainfall and K fertilization effects



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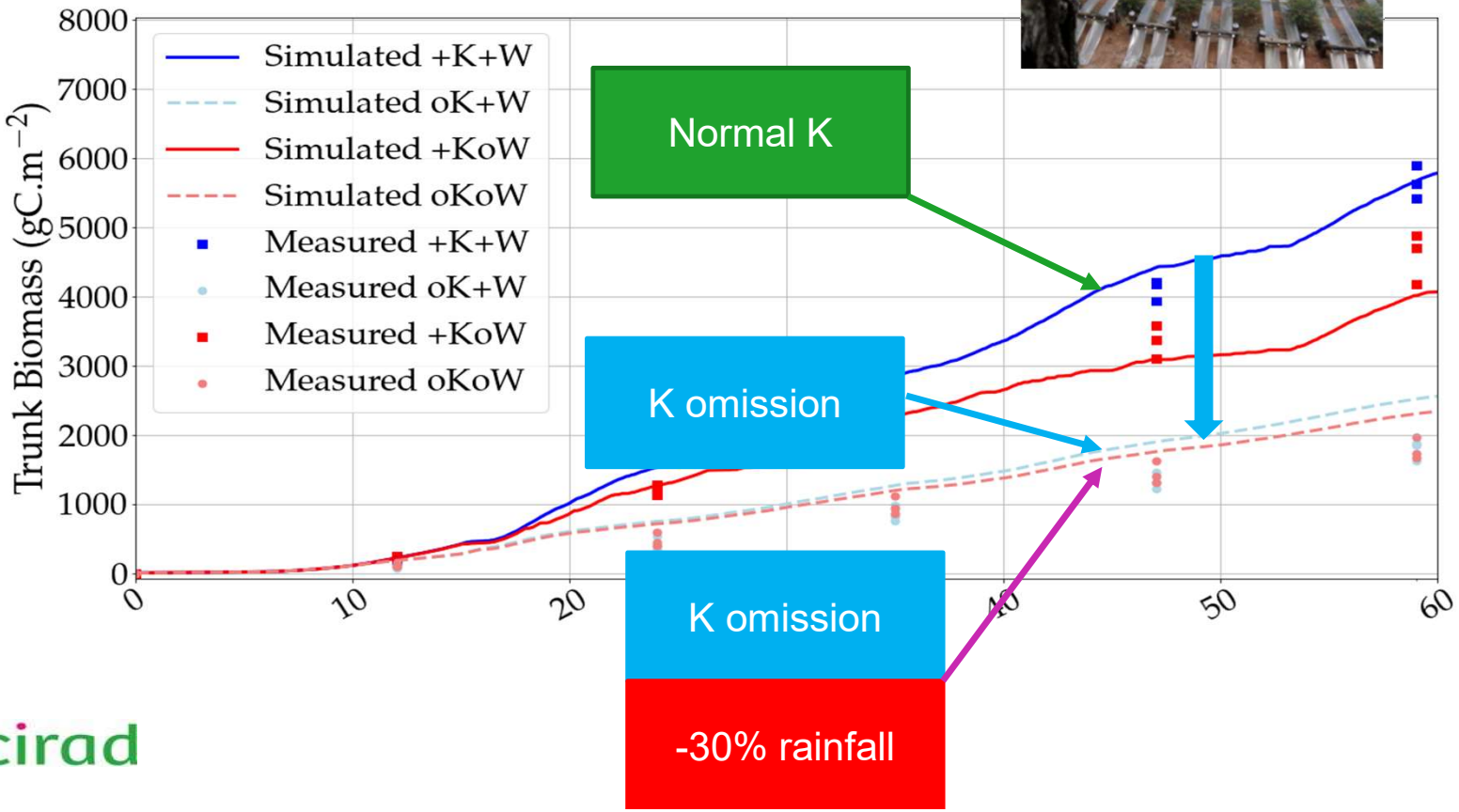
Model test for rainfall and K fertilization effects



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Current challenges and perspectives linked with digital science

- Use of **meta-models** to upscale from trees to stand in mixed plantation contexts
- Application of the Castanea-Maespa model at large scale using **data assimilation** from remote sensing (multiple forcing variables: LAI, surface temperature, etc.)
- *Other ongoing topic: detection of growth anomaly by remote sensing using **time-series** of different sensors*

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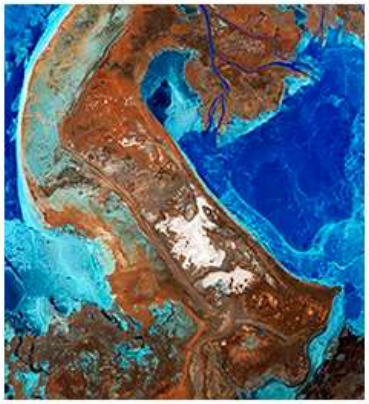
TERRITOIRE ENVIRONNEMENT TÉLÉDÉTECTION INFORMATION SPATIALE

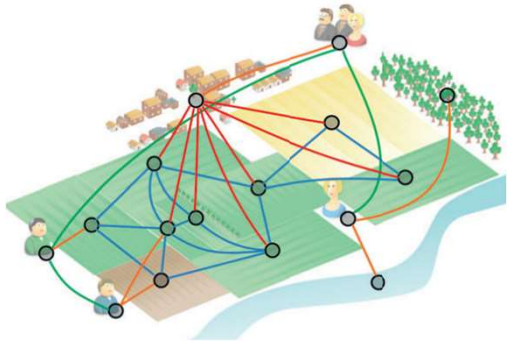
Territory, Environment, Remote sensing & Spatial Information

Focus on developing the use of spatial information to understand territorial complexity, agro-ecosystems and support for stakeholders.

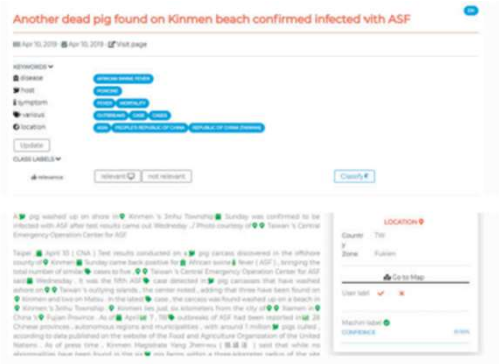
Acquisition, remote sensing, processing and space observations



Spatial Analysis and Modelling



Heterogeneous Data science and Information Systems



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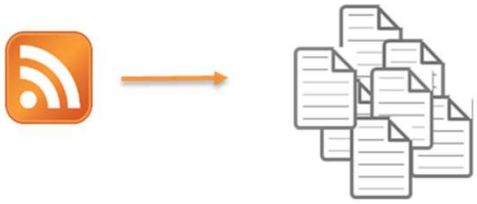
Textual data: which tasks ?

- How to collect data?

Web scraping



- What is the data about?

Named entity extraction

dates

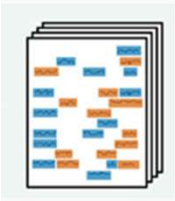
localisation

thematic entities

- How to select relevant data?

Automatic classification

- What are the relationships between entities?



Co-occurences

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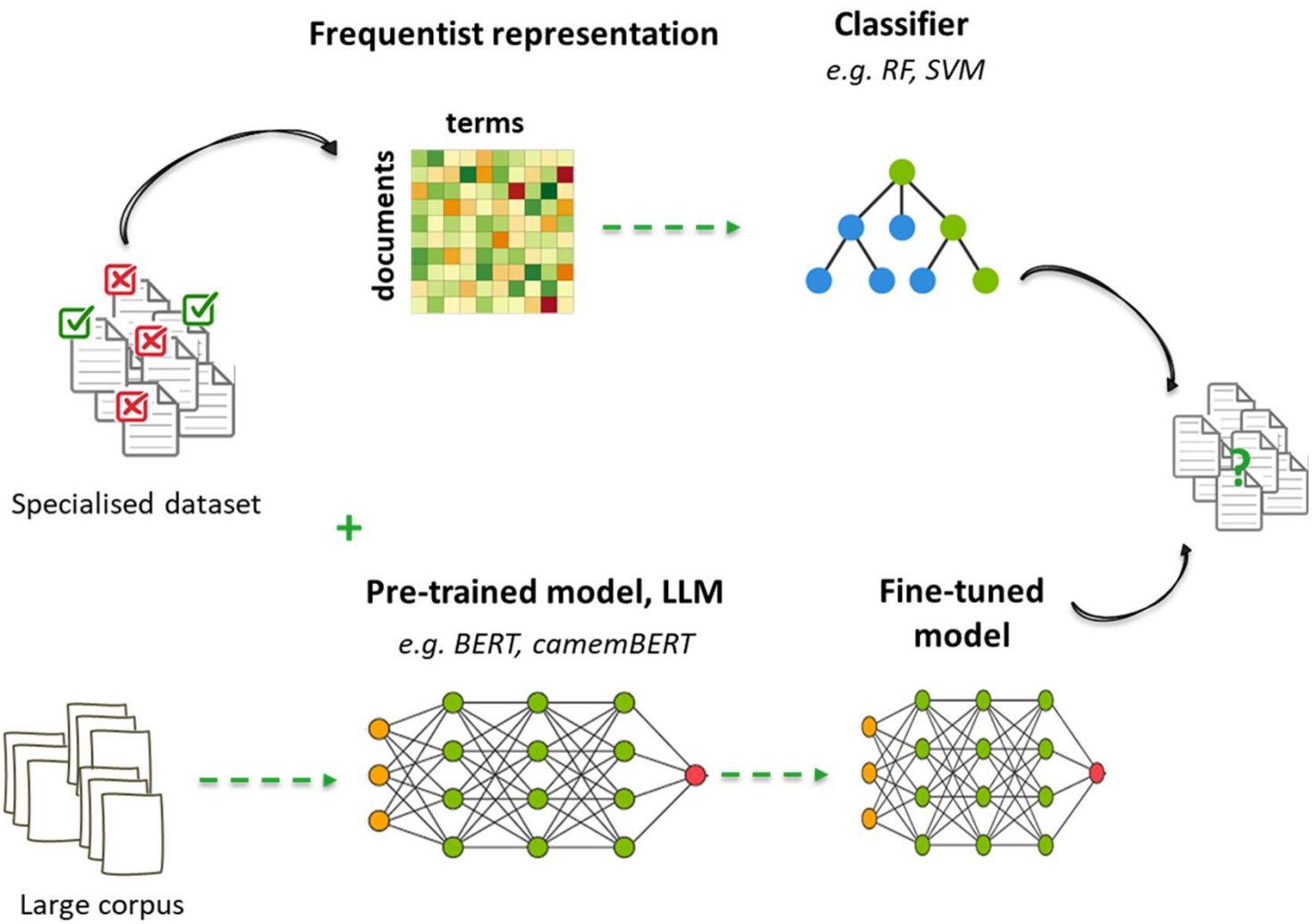
Textual data & specialised applications - challenges



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Textual data for monitoring animal diseases

PADI - WEB

Mystery illness ravages Muscovy ducklings

- GLDA hatchery closed after increased mortality seen

① **Data collection**

Google News

② **Data processing**

- Text cleaning
- Language detection
- English translation

③ **Data classification**

Relevant document

Irrelevant document

④ **Sentence classification**

Event type
Information type

⑤ **Information extraction**

- ✓ Disease
- ✓ Host
- ✓ Location
- ✓ Date
- ✓ Number of cases
- ✓ Symptoms

⑥ **Email Notifications**

and/or Website consultation
https://padi-web.cirad.fr/en/

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https://padi-web.cirad.fr/en/

Textual data for monitoring animal diseases

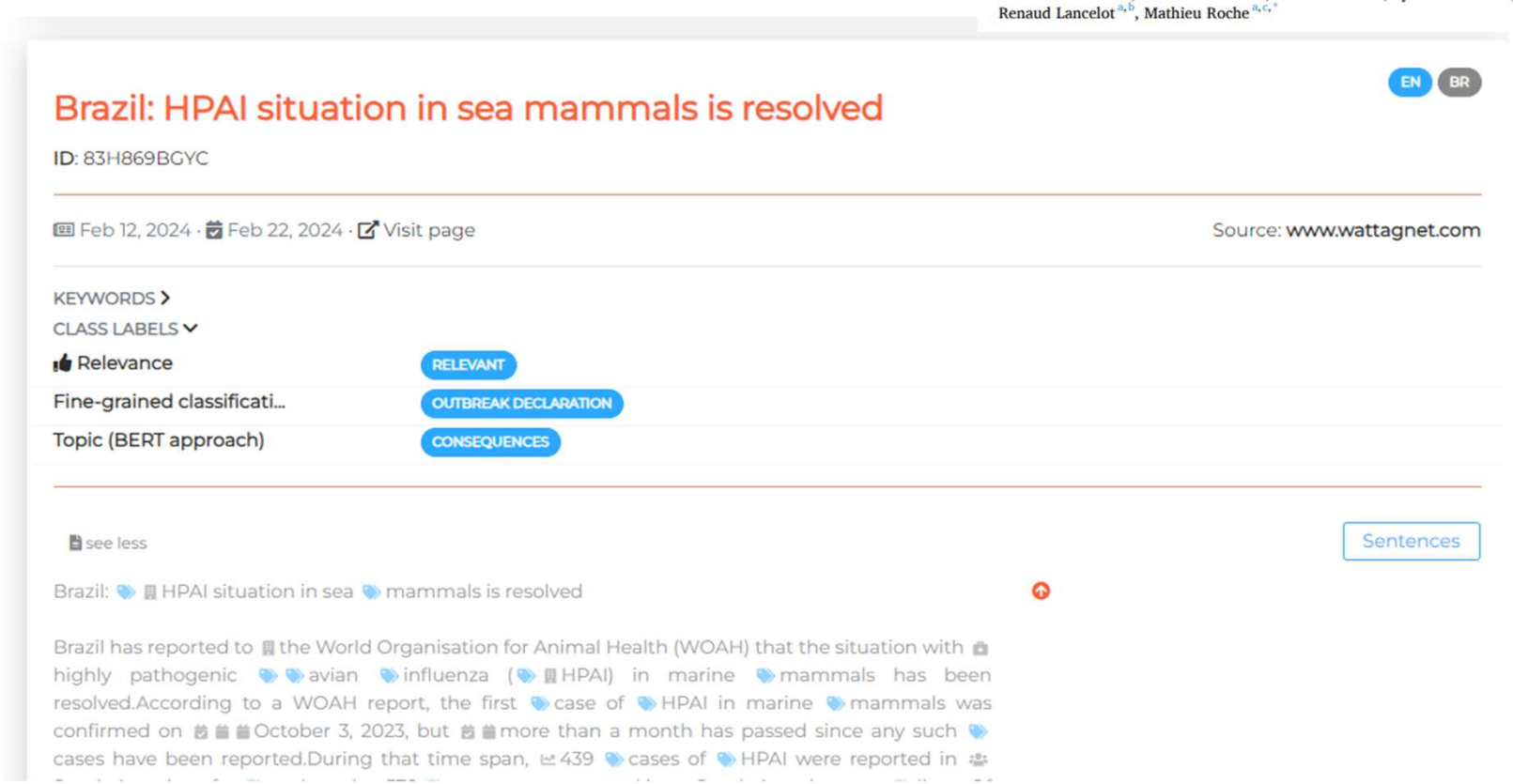
Contents lists available at ScienceDirect

One Health

journal homepage: www.elsevier.com/locate/onehlt

PADI-web 3.0: A new framework for extracting and disseminating fine-grained information from the news for animal disease surveillance

Sarah Valentin [a,b,c], Elena Arsevska [a,b], Julien Rabatel [a], Sylvain Falala [a,b], Alizé Mercier [a,b], Renaud Lancelot [a,b], Mathieu Roche [a,c,*]



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Textual data for monitoring food crises

Google News

YouTube

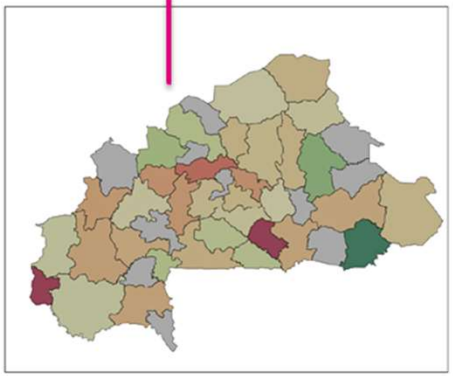
Journal of Intelligent Information Systems
https://doi.org/10.1007/s10844-023-00832-x

RESEARCH

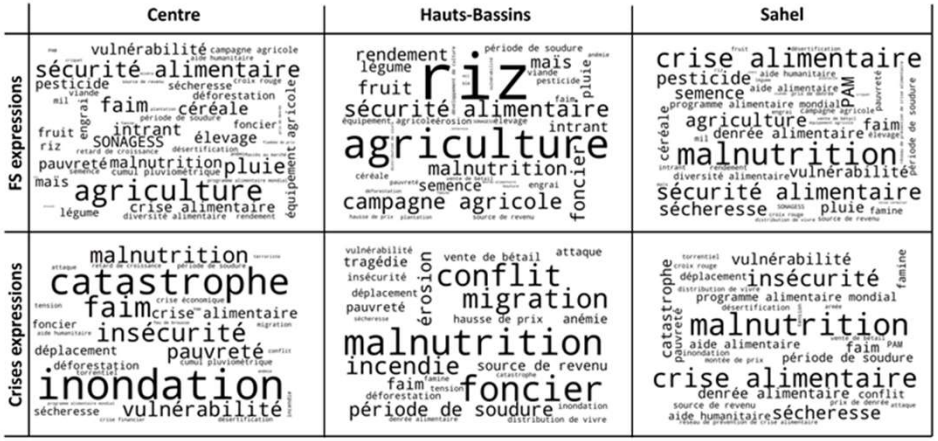
How can text mining improve the explainability of Food security situations?

Hugo Deléglise[1,2] · Agnès Bégué[1,2] · Roberto Interdonato[1,2] · Elodie Maître d'Hôtel[3,4] · Mathieu Roche[1,2] · Maguelonne Teisseire[1,5]

Foodstuffs in the North, Prices soar



(c) *TXT-FS* on Articles



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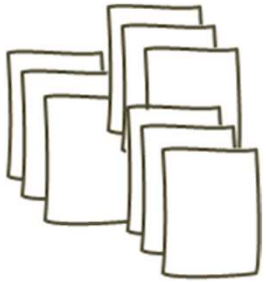
Textual data & remote sensing: perspectives

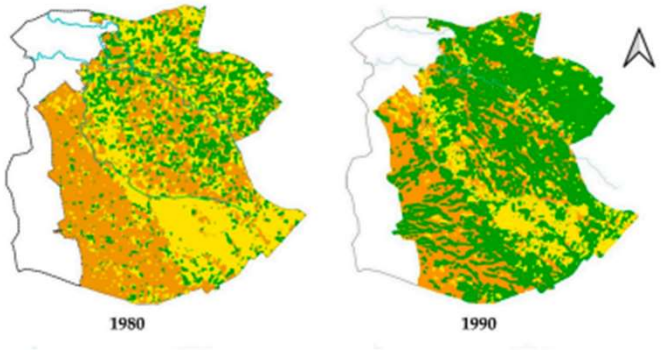


Specialised ressources

Land use and land cover changes & their drivers

"From 1984 to 2001, bare soils and agricultural lands increased by 17% and 18%. "

Land use and land cover change maps (RS)



From *Kadri et al. Remote Sens. 2023, 15, 3257.*

How to combine ?

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EVERGREEN

Earth observation and machine learning for agri-environmental challenges

https://team.inria.fr/evergreen/

- transferability of multimodal classification models
- design of machine learning models for low-data-regime scenarios
- interpretability and explicability of classification algorithms for image and time-series data

Contacts

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Roberto Interdonato (roberto.interdonato@cirad.fr)
Diego Marcos (diego.marcos@inria.fr)

Thank you for your attention