



Non-Permanent member Day

26/04/24



# The impact of climate change on desert locust population dynamics using agent-based model (ABM)



**PhD** : 15/10/21 - 31/01/25

**By** : Fanny Herbillon



Supervision

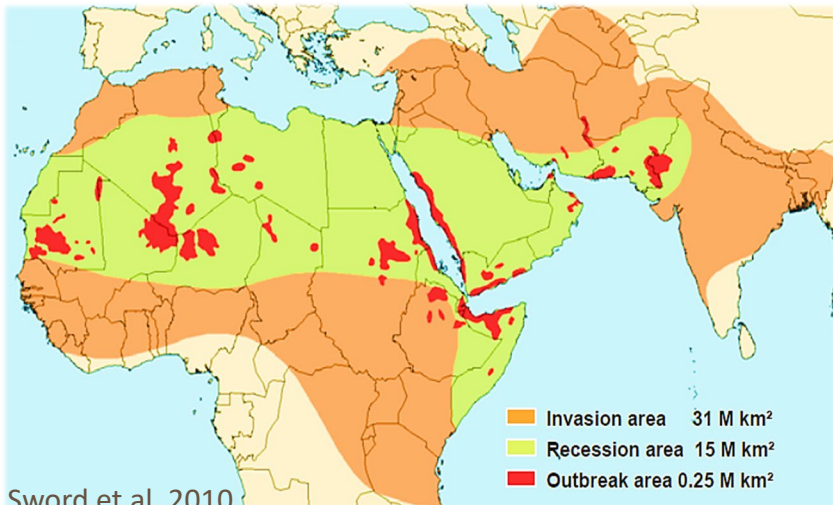
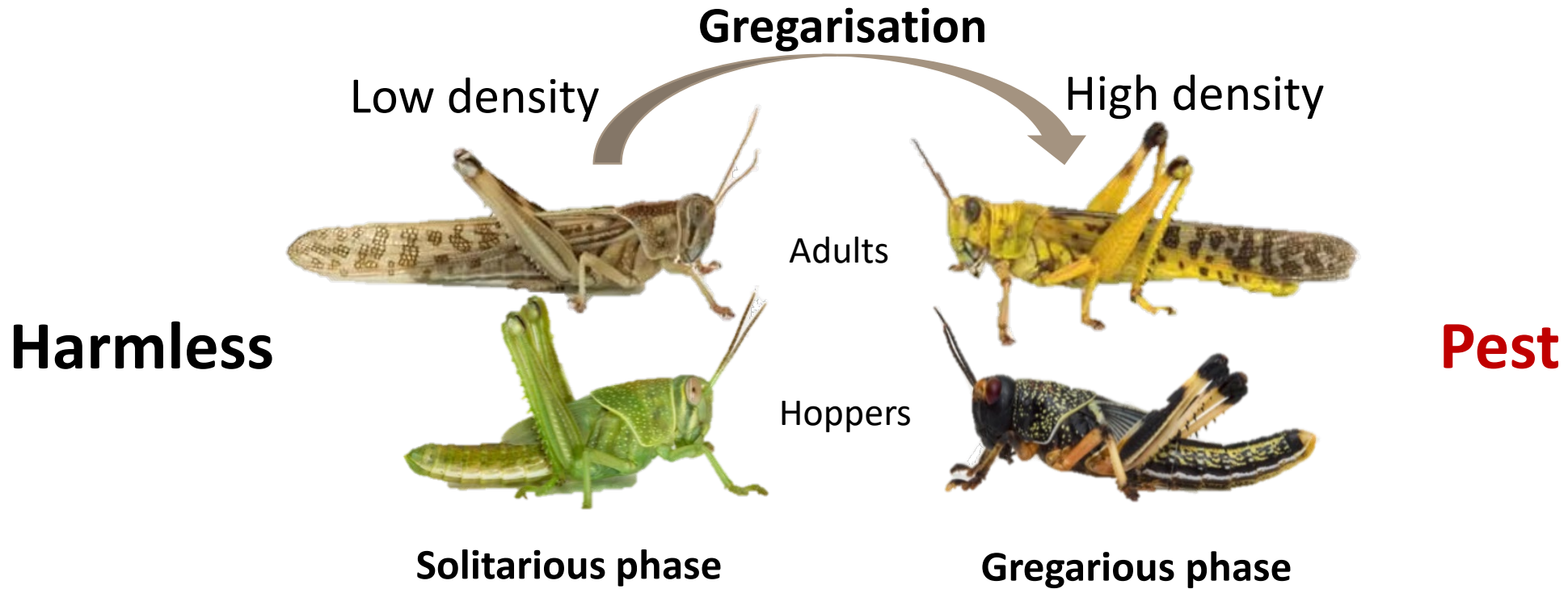
**Christine MEYNARD**

UMR CBGP, INRAE Montpellier  
Statistical modelling

**Cyril PIOU**

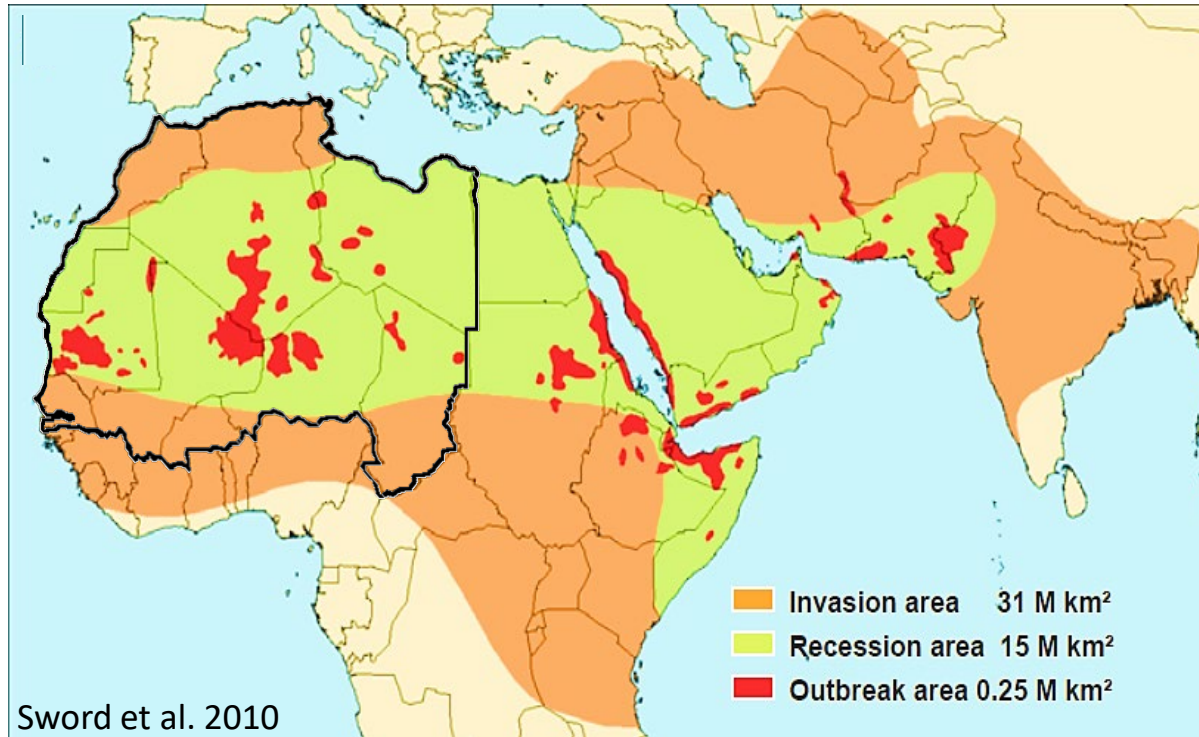
UMR CBGP, CIRAD Montpellier  
Mechanistic modelling





## 2003–2005 West Africa locust crisis

20 countries treated (~130,000 km<sup>2</sup>)  
The costs of fighting > US\$400 million  
Harvest losses valued up to US\$2.5 billion  
(estimations from the FAO)



**Chemical control**  
Preventive strategy

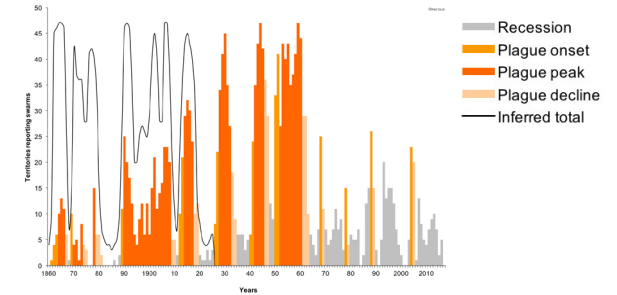
## To help manage the desert locust :

Is there a risk of outbreaks ?

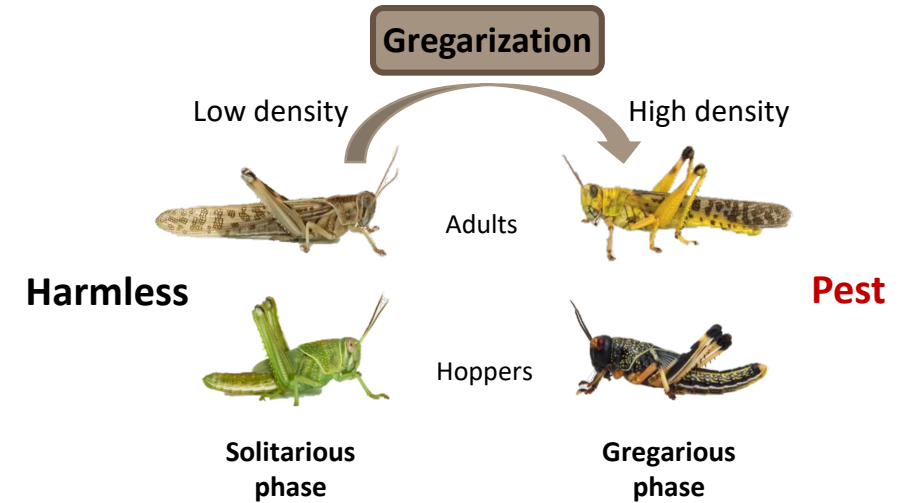
Where ?

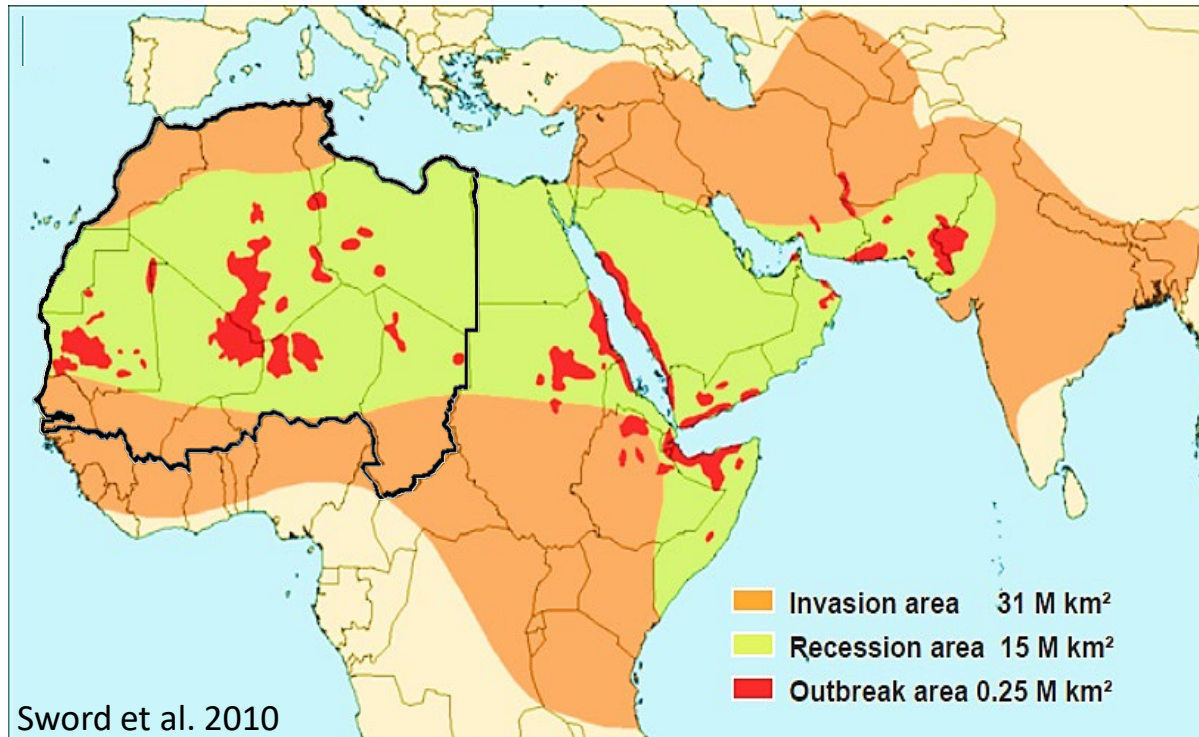
When ?

Evolution in the future (short-term & long-term)



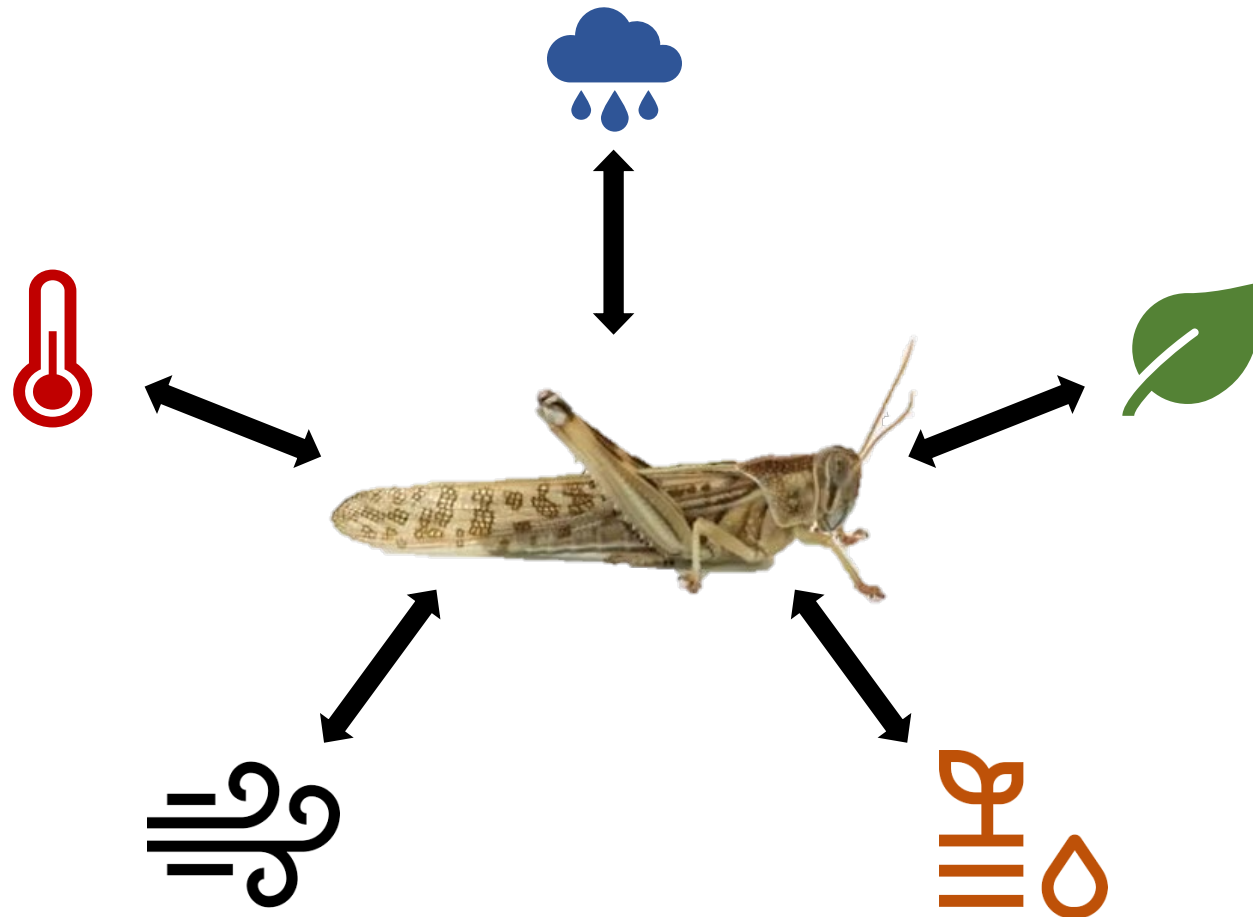
Sign of locust outbreak





**CLCPRO** region ~ 10,5 million km<sup>2</sup>

**CLCPRO** = Commission for the Control of the Desert Locust in the Western Region



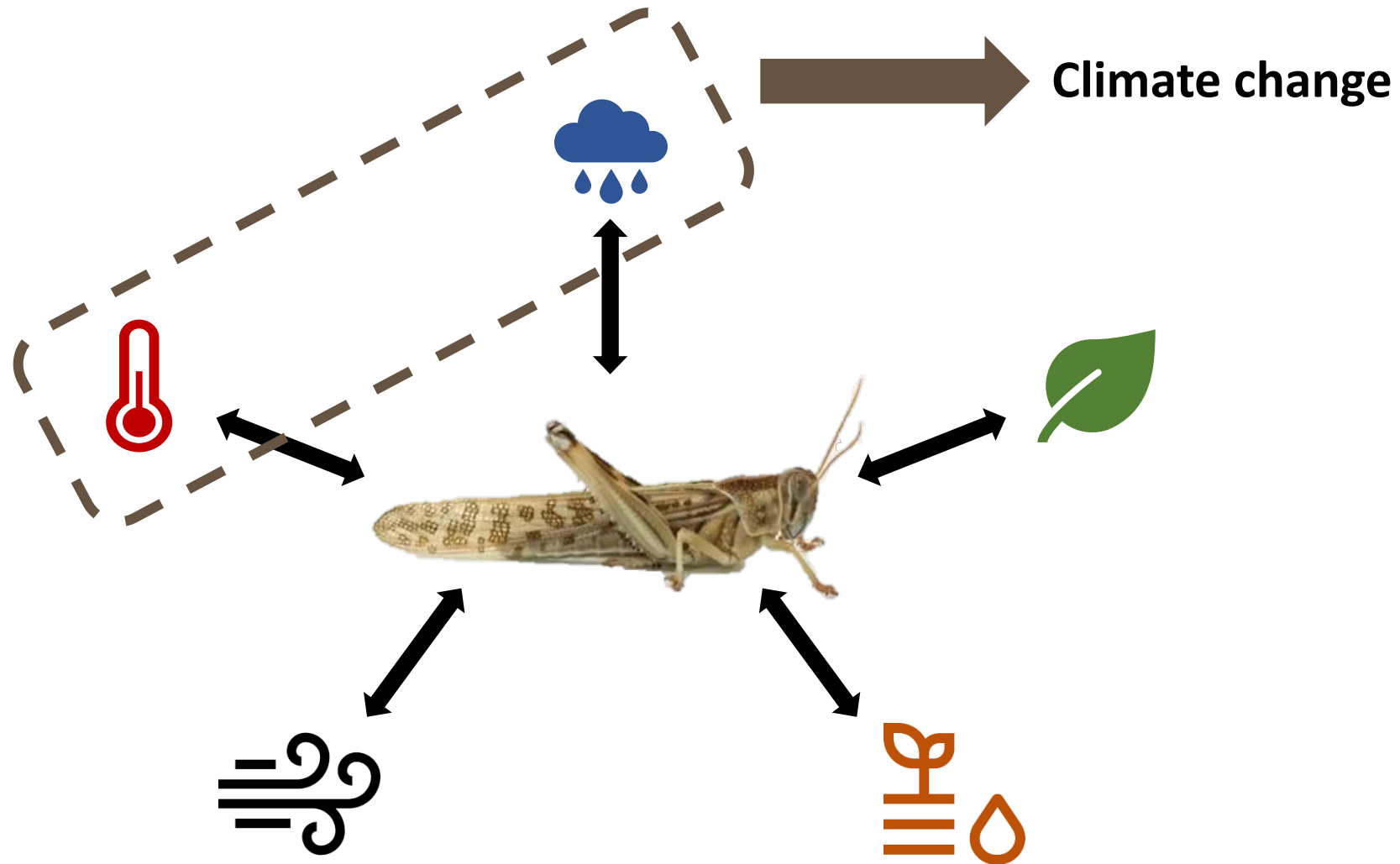
**Ectotherm**

**Food Sources**

**Shelter**

**Reproduction**

**Movement**



## Chap 2

Develop a **mechanistic model** capable of reproducing desert locust **population dynamics**, based only on climate ( **$T^\circ$  et pp**)

### **Challenges:**

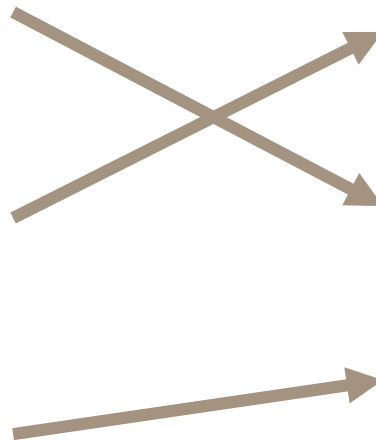
- **Large-scale** model (CLCPRO)
- **Gregarization** phenomenon
- Seasonal **migration** cycle
- **Climatics variables only**

## Chap 3

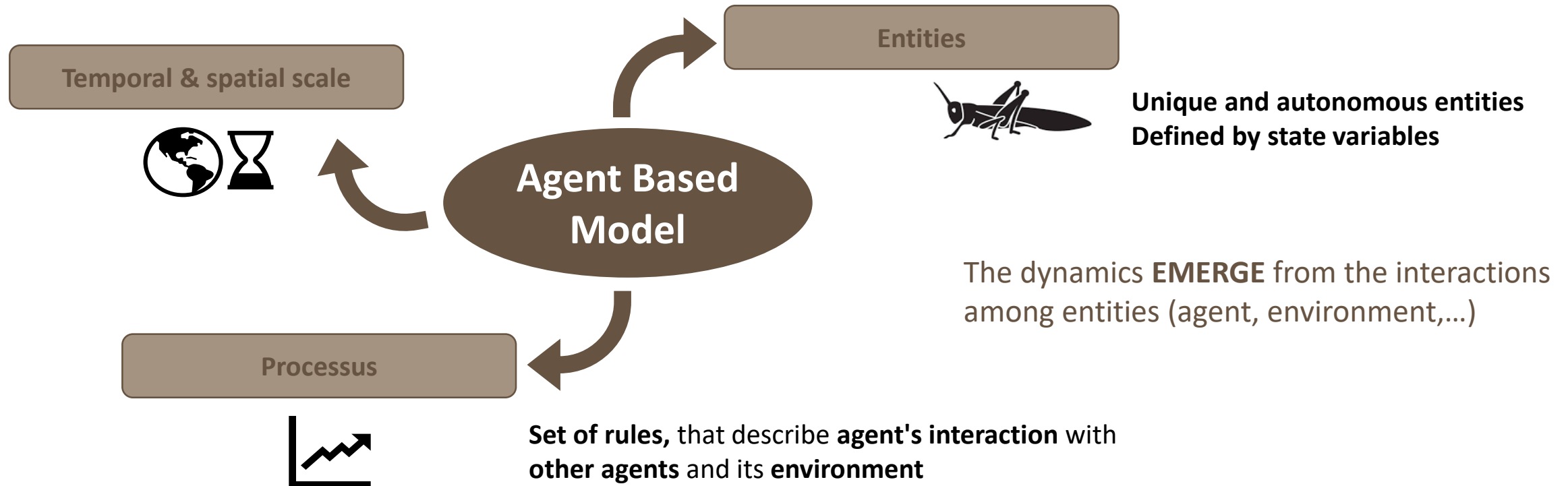
**Future risk predictions** of Desert locust population dynamics in a context of **climate change**

### **Objectives:**

- **Population dynamics simulations**
- **Realist cartography of CLCPRO**
- **Climate change scenarios over 50 years**



## What is an ABM?





## Environment

Spatially explicit

CLCPRO map

Cells 50x50km

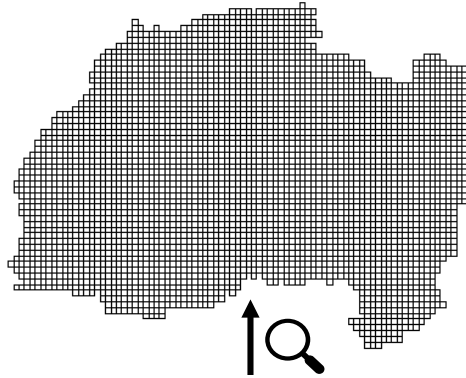


## Environment

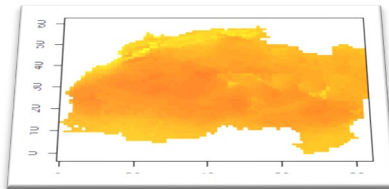
Spatially explicit

CLCPRO map

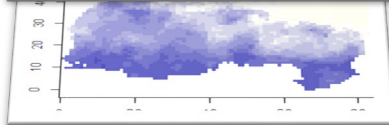
Cells 50x50km



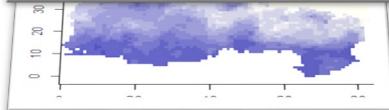
Temperature (t)



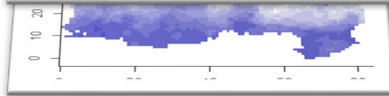
Precipitations (t)



Precipitations (t-1)



Prcipitations (t-2)



# Model

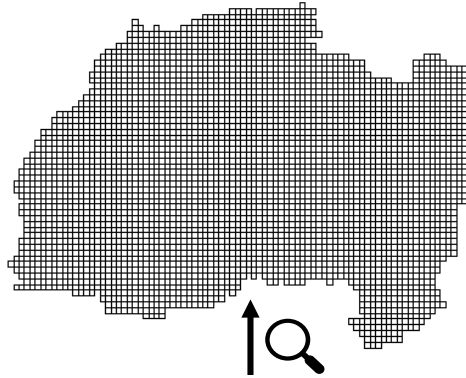
# My agent-based model

## Environment

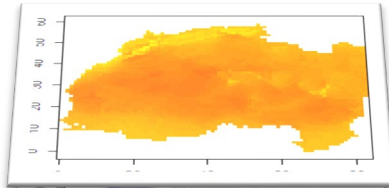
Spatially explicit

CLCPRO map

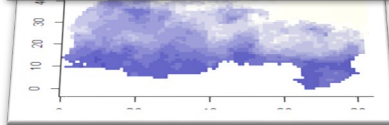
Cells 50x50km



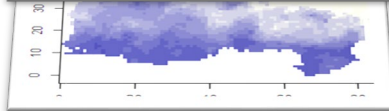
Temperature (t)



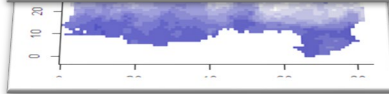
Precipitations (t)



Precipitations (t-1)



Prcipitations (t-2)



## Agents



# Model

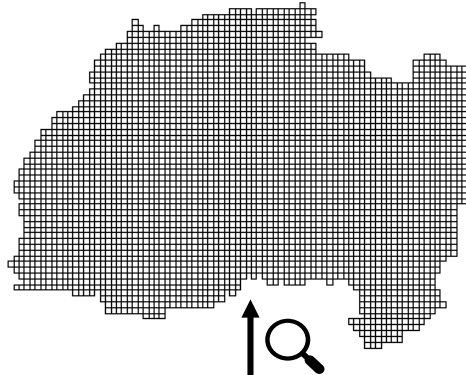
# My agent-based model

## Environment

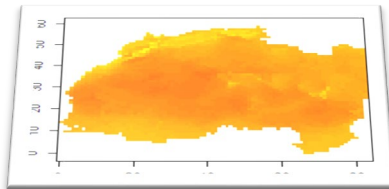
Spatially explicit

CLCPRO map

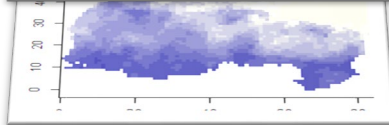
Cells 50x50km



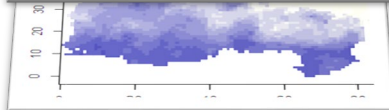
Temperature (t)



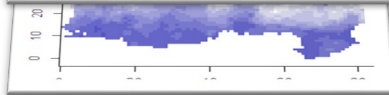
Precipitations (t)



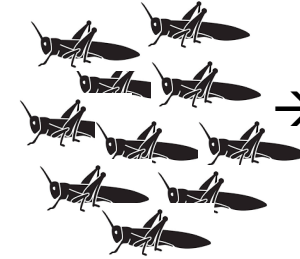
Precipitations (t-1)



Prcipitations (t-2)



## Agents



→ Facilitate simulation

"super-agent" = cohort

# Model

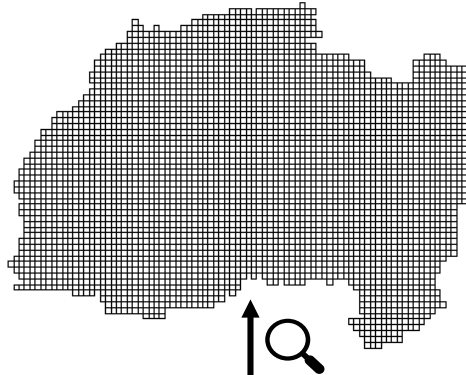
# My agent-based model

## Environment

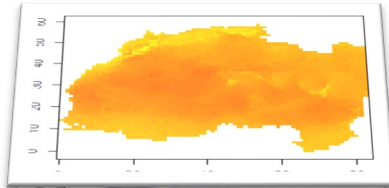
Spatially explicit

CLCPRO map

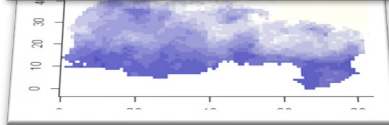
Cells 50x50km



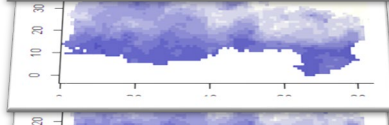
Temperature (t)



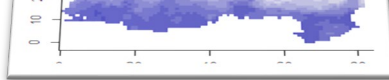
Precipitations (t)



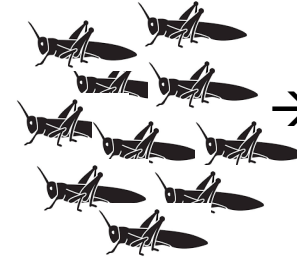
Precipitations (t-1)



Prcipitations (t-2)



## Agents



→ Facilitate simulation

"super-agent" = cohort

**State variables**

Structure

- Age (d)
- Stage (egg, hopper L1 to L5 or mature adult)
- Phase (solitarious or gregarious)
- ...

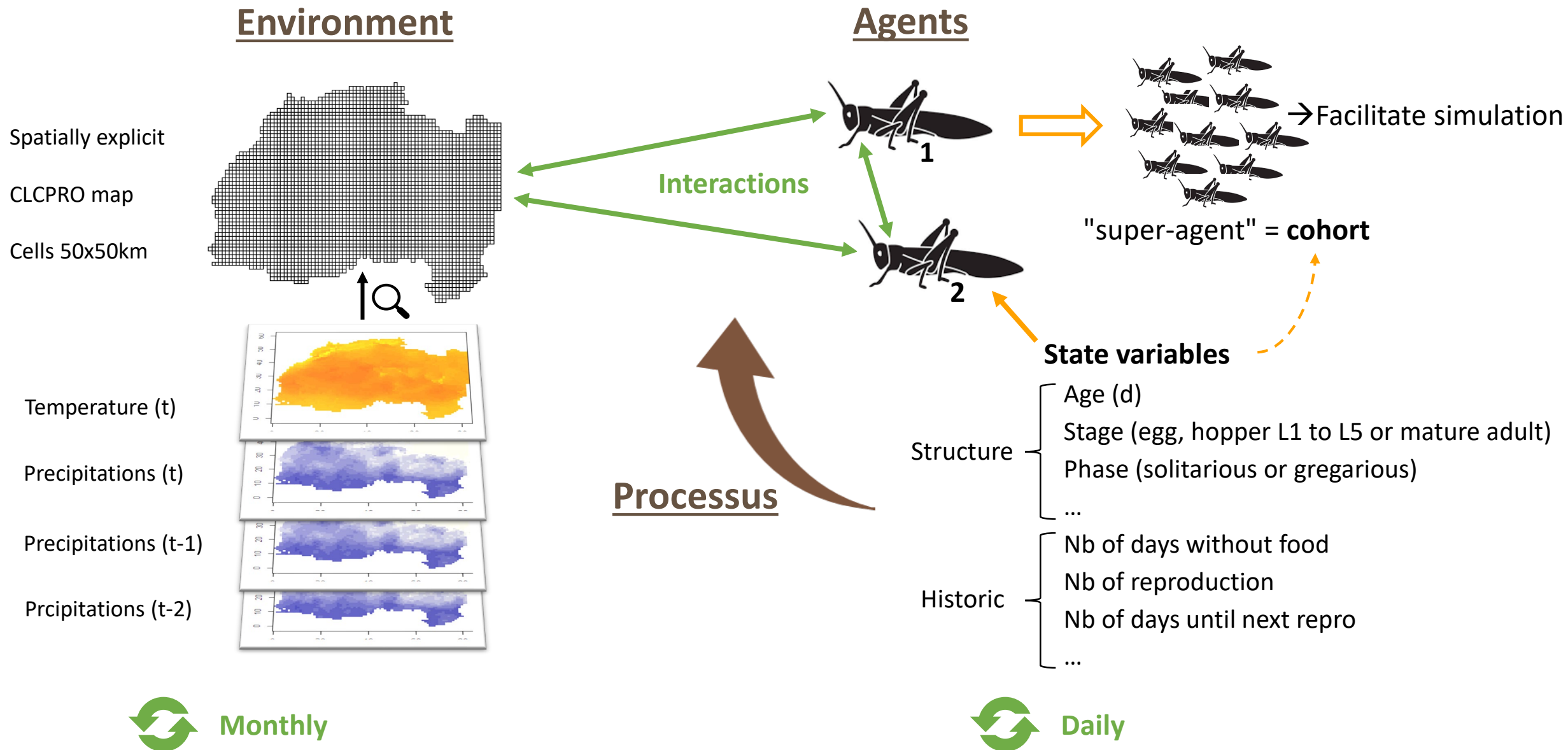
Historic

- Nb of days without food
- Nb of reproduction
- Nb of days until next repro
- ...



# Model

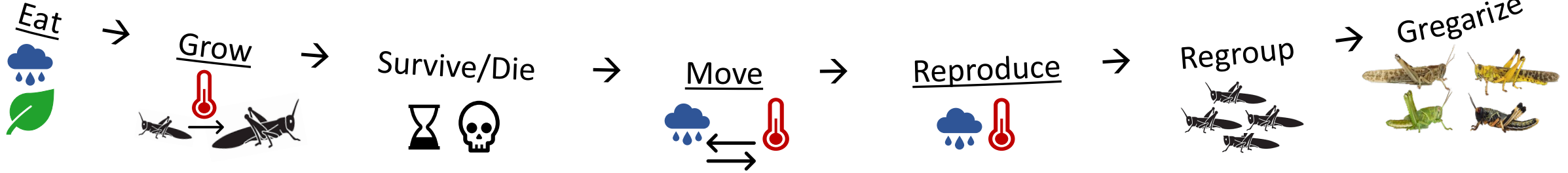
# My agent-based model



# Model

# Processus

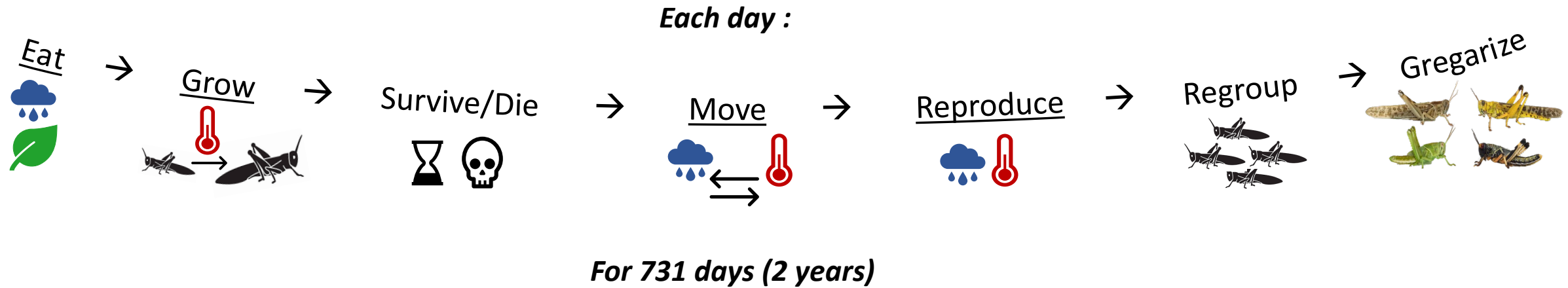
*Each day :*



*For 731 days (2 years)*

# Model

# Processus



## Processus



Depends on knowledge on the species

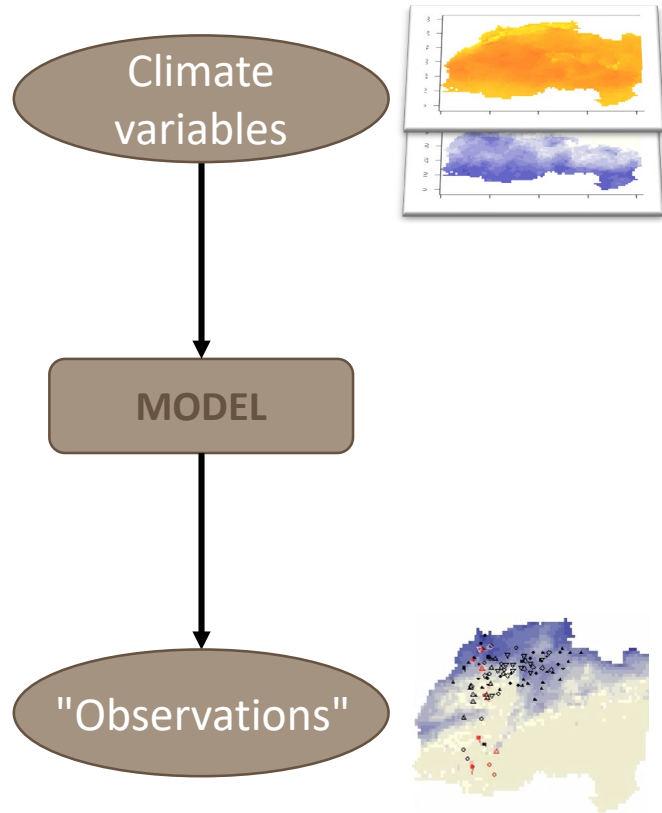
Literature when biological parameters are conform to the model

**BUT** others are specific to our 50x50km, monthly/daily model



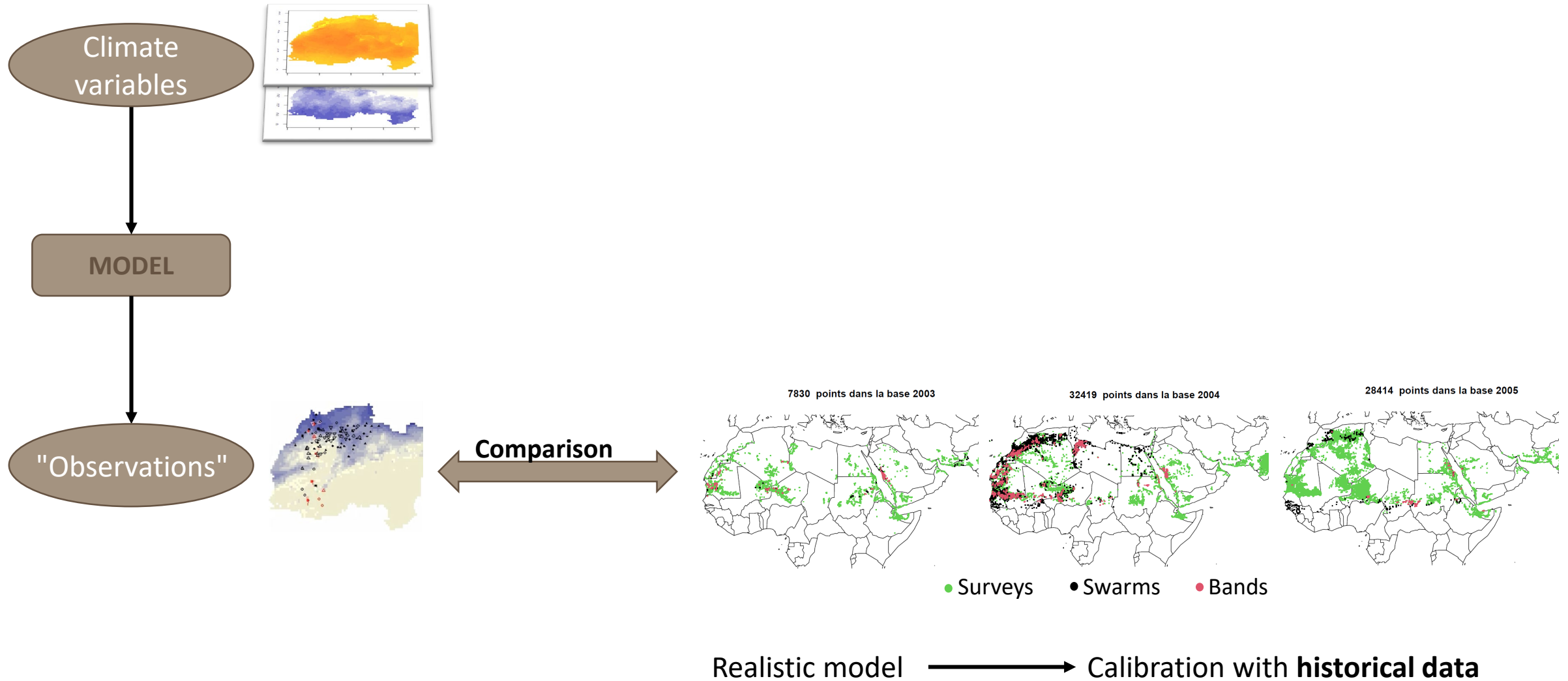
**to calibrate**





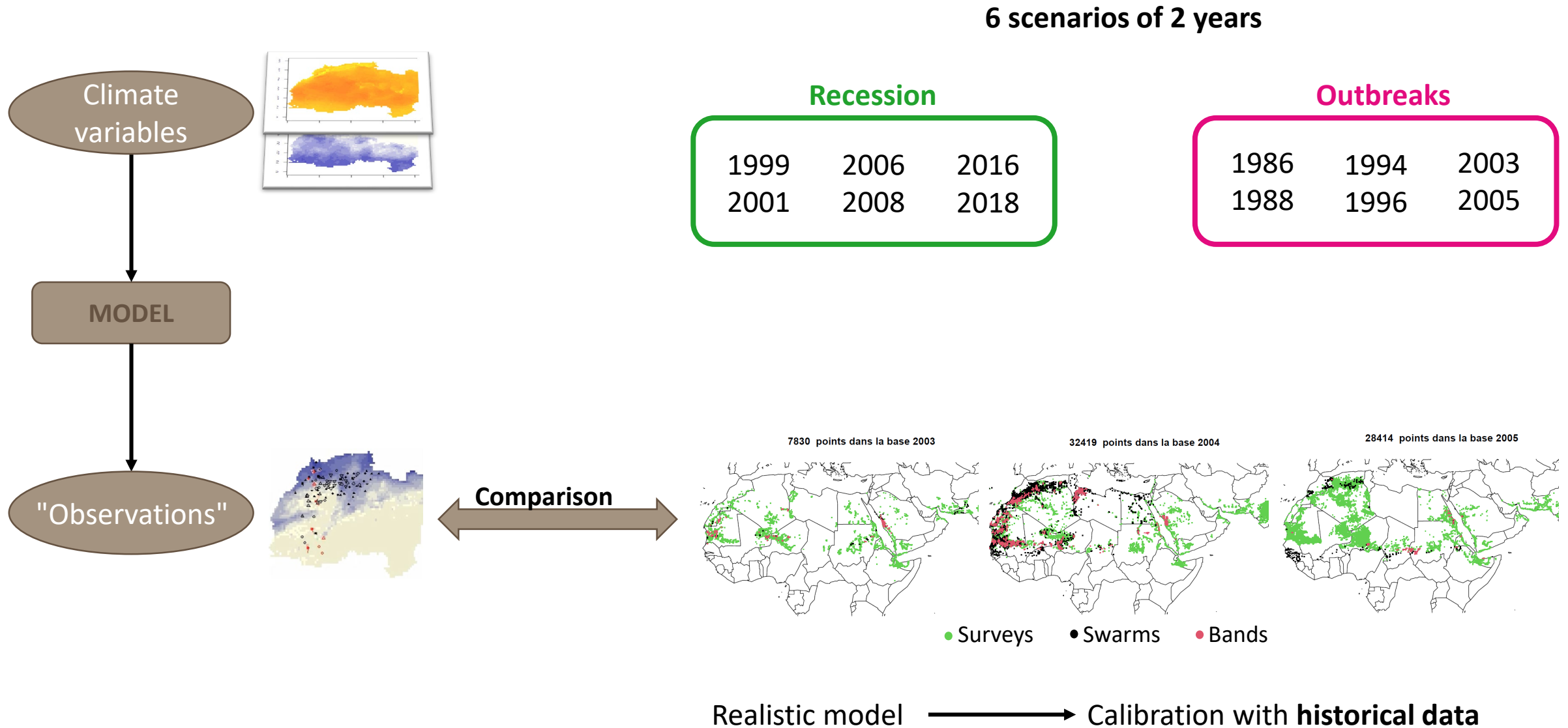
# Model

# Calibration & Validation



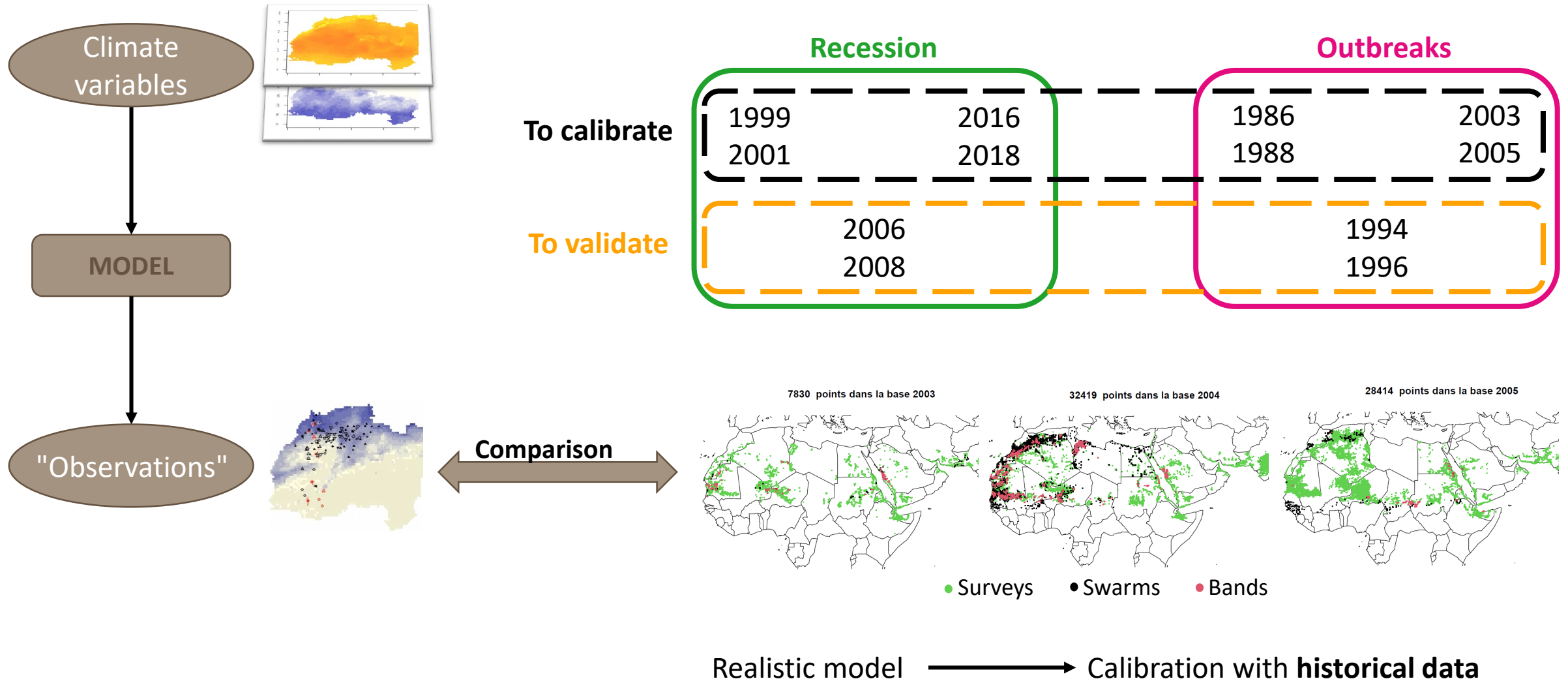
# Model

# Calibration & Validation



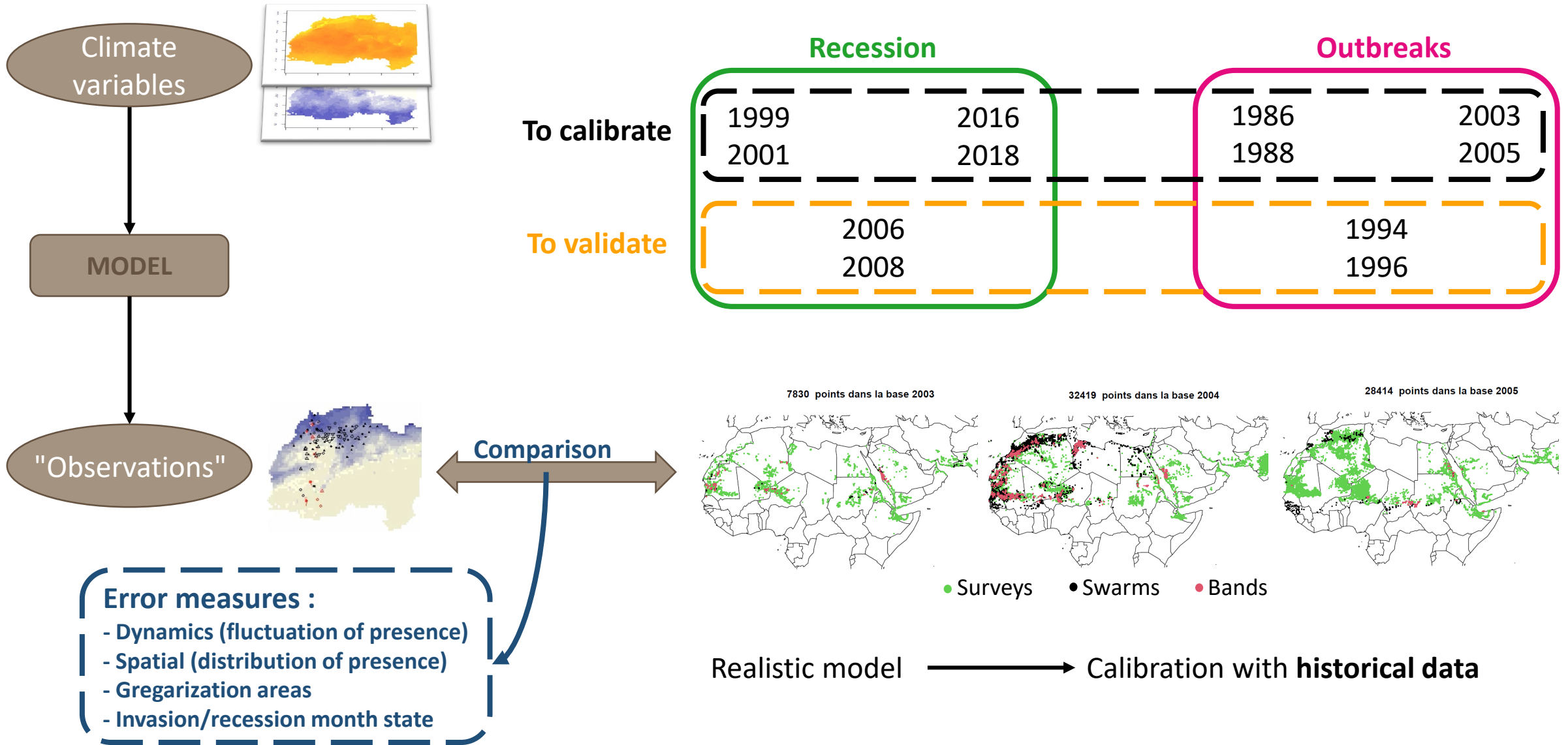
# Model

# Calibration & Validation



# Model

# Calibration & Validation



# Model

# Calibration & Validation

## Error measures :

- Dynamics (fluctuation of presence)
- Spatial (distribution of presence)
- Gregarization areas
- Invasion/recession month state



Use of reference error  
threshold values



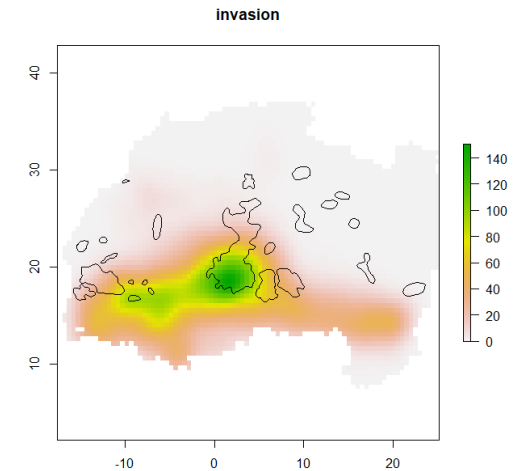
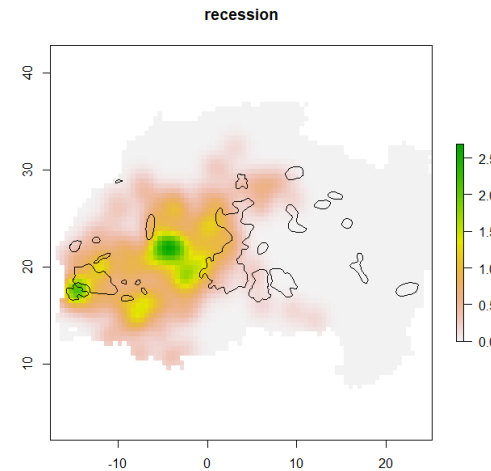
4 parameterizations selected /40320 explored  
x2 to ≠ recession/invasion with low/high density  
(6 calibrated parameters)

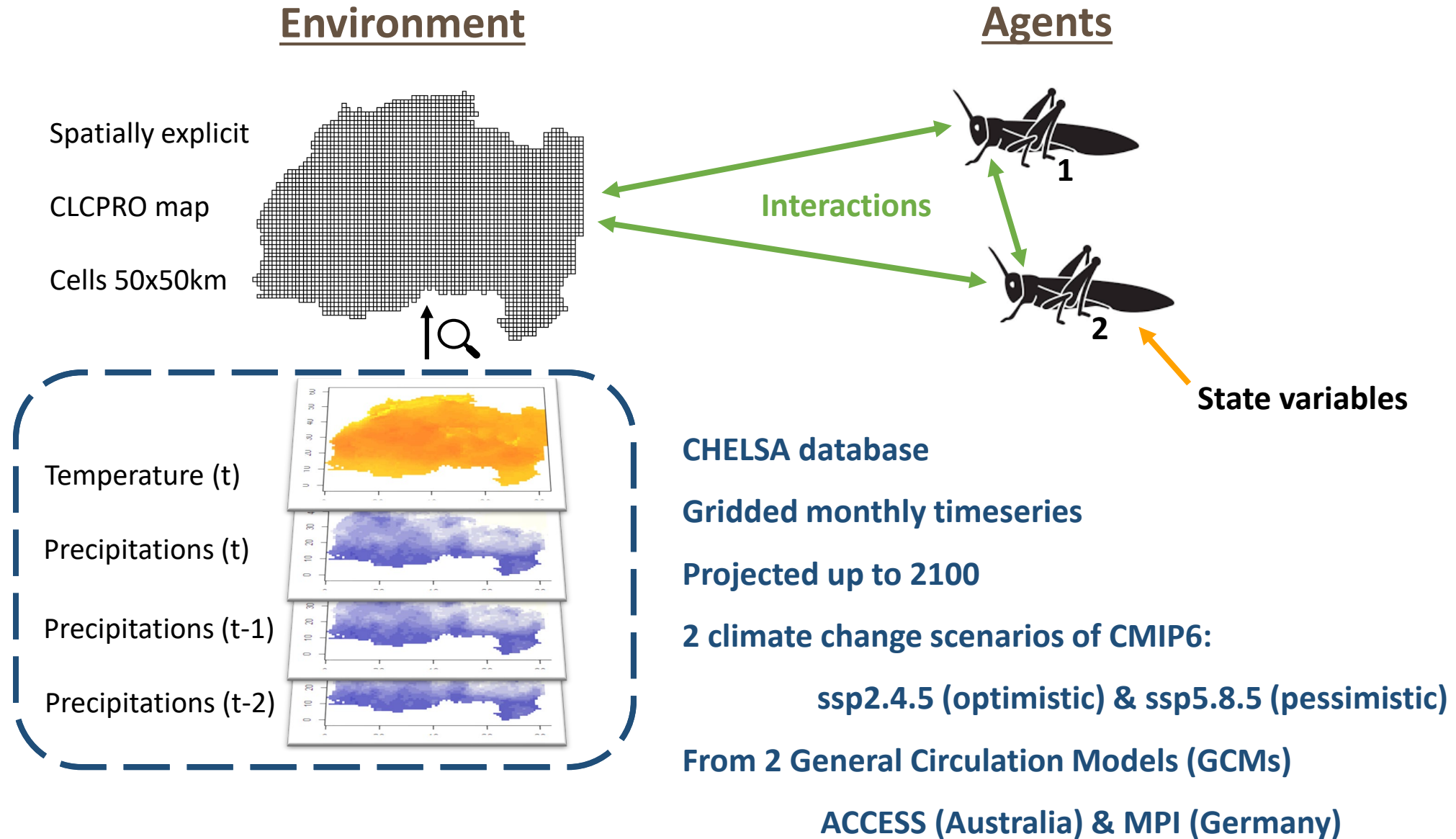
**Dynamic error :**  
Recession = 0,24  
Invasion = 0,25

**Spatial error :**  
Recession = 0,43  
Invasion = 0,7

**Inva/recess error :**  
Recession = 0,05  
Invasion = 0,48

## Gregarization areas :





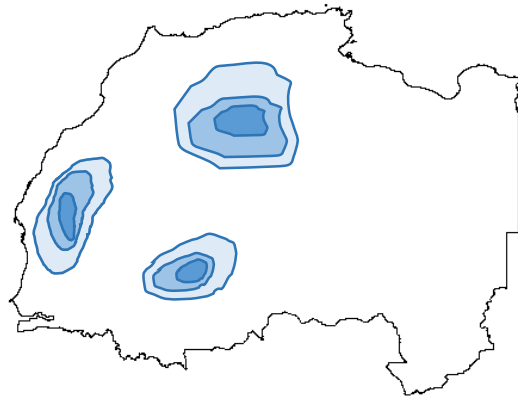
## Frequency of gregarization

= number of gregarious transition events (adults & hopper)

$N_{recession} < N_{invasions}$

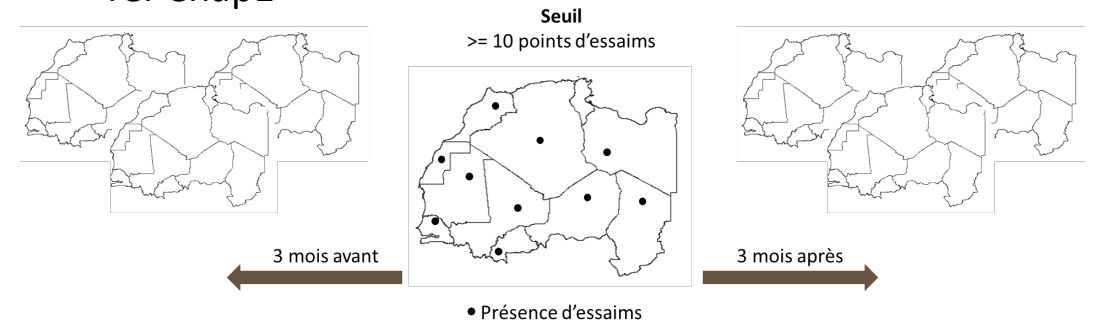
## Gregarization areas

= buffer on gregarization areas from all simulations



## Categorisation recession/invasion

= ref Chap1







- Creation of a model integrating biological and ecological processes,



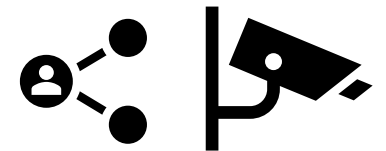
- Including climate influences on locust survival, reproduction and movement.

- Assess how populations might respond to climate change in the future.



- Identify areas that could become more at risk from outbreaks, and where monitoring needs to be stepped up.

- Encourage maintenance of management efforts and resources.



→ Reduce pressure on already fragile food security and minimize the impact of pesticide management on the environment.

*Thanks for your attention*



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Supervision :

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