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and Life Sciences, Vienna
Department of Economics and Social Sciences

Integrated modelling of crop rotation regulations to control Western Corn Rootworm under climate change in Austria

Global Land Programme: 4th Open Science Meeting 2019
Opportunities of farm and landscape level models in land use science for biodiversity and ecosystem service assessment

Katharina Falkner, Hermine Mitter, Elena Moltchanova, Erwin Schmid

Mit Unterstützung von Bund, Ländern und Europäischer Union
Bundesministerium Nachhaltigkeit und Tourismus
LE 14-20
Entwicklung für den Ländlichen Raum
Europäischer Landwirtschaftsfonds für die Entwicklung des ländlichen Raums: Hier investiert Europa in die ländlichen Gebiete.

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Overview

- Research background
- Research objectives
- Material & Methods
  - Integrated modelling framework
  - Assumptions and scenarios
- Results
  - Economic effects
  - Western Corn Rootworm (WCR) abundance
- Conclusions

Research background

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The Western Corn Rootworm (WCR; *Diabrotica virgifera vigifera*)

- non-native species
  - origin: North America
  - invasive spreading
  - ecological and economic damages

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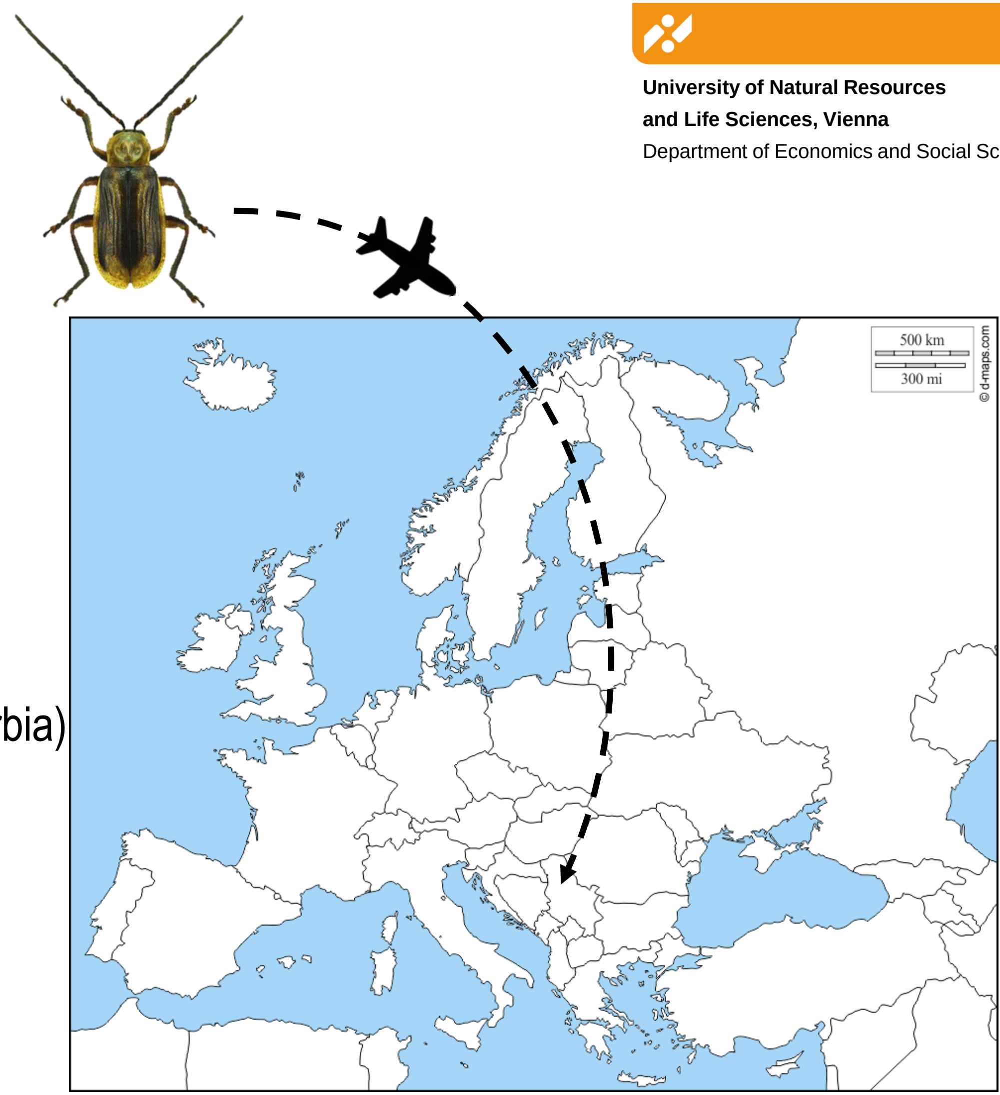
- non-native species
  - origin: North America
  - invasive spreading
  - ecological and economic damages
- Europe
  - 1st detection in 1992 (Belgrade, Serbia)
  - continuous spread westwards

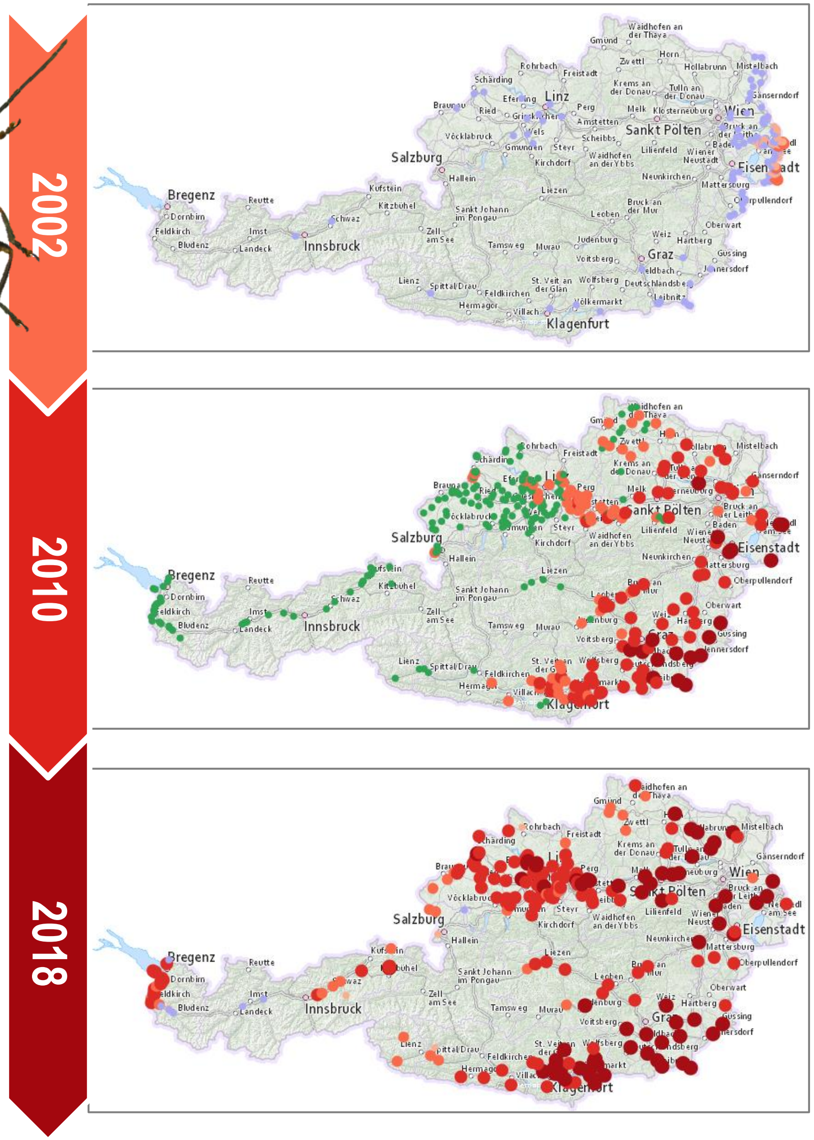


Source: d-maps.com. 2017-2019. Länderkarte Europa.
URL: https://d-maps.com/carte.php?num_car=2232&lang=de. [Accessed: 15.04.2019]

Research background

The Western Corn Rootworm (WCR; *Diabrotica virgifera vigifera*)

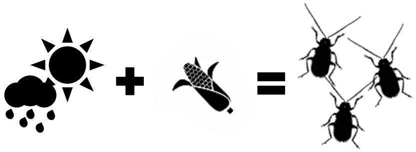
- non-native species
  - origin: North America
  - invasive spreading
  - ecological and economic damages
- Europe
  - 1st detection in 1992 (Belgrade, Serbia)
  - continuous spread westwards
- Austria
  - 1st detection in 2002
  - highest economic damages in 2014
  - WCR monitoring via pheromone traps



no infestation · WCR at least in 1 week · WCR at least in 4 weeks · weeks with >100 WCR

Source: AGES. Diabrotica interactive map. URL: https://geogis.ages.at/GEOGIS_DIABROTICA.html. [Accessed 15.04.2019].

Research background



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Influencing factors on WCR spread and infestation

- Natural spread
- Maize production intensity (share of cropland under maize production)
- Climatic conditions
  - life cycle development
  - climate change → northward shift in cropping zones

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Research objectives

We aim at

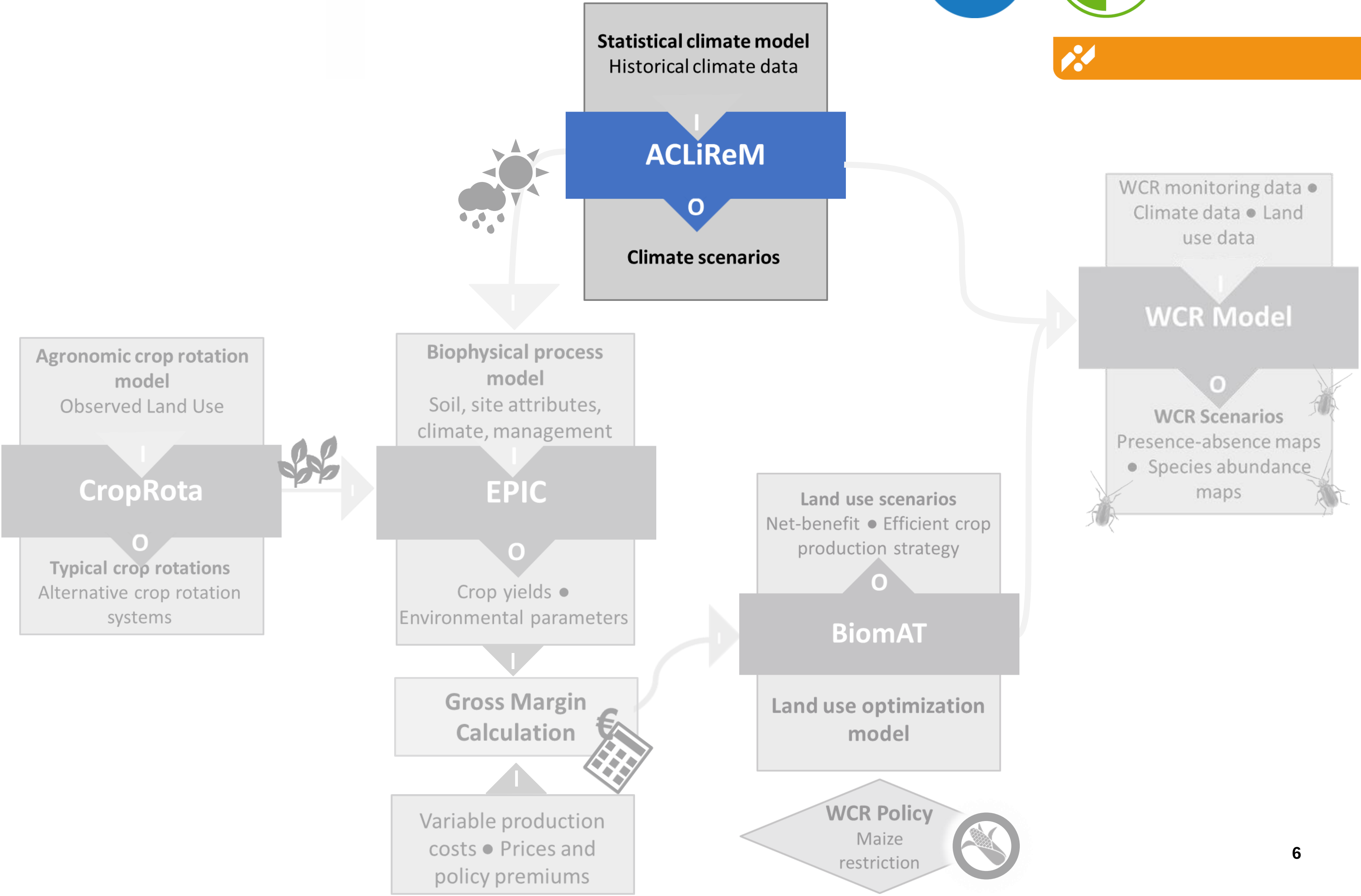
a) analysing the **effect of crop rotation regulations** with upper limits for maize shares on WCR infestation under **climate change** in Austria.

b) identifying effective and efficient management strategies to control WCR.

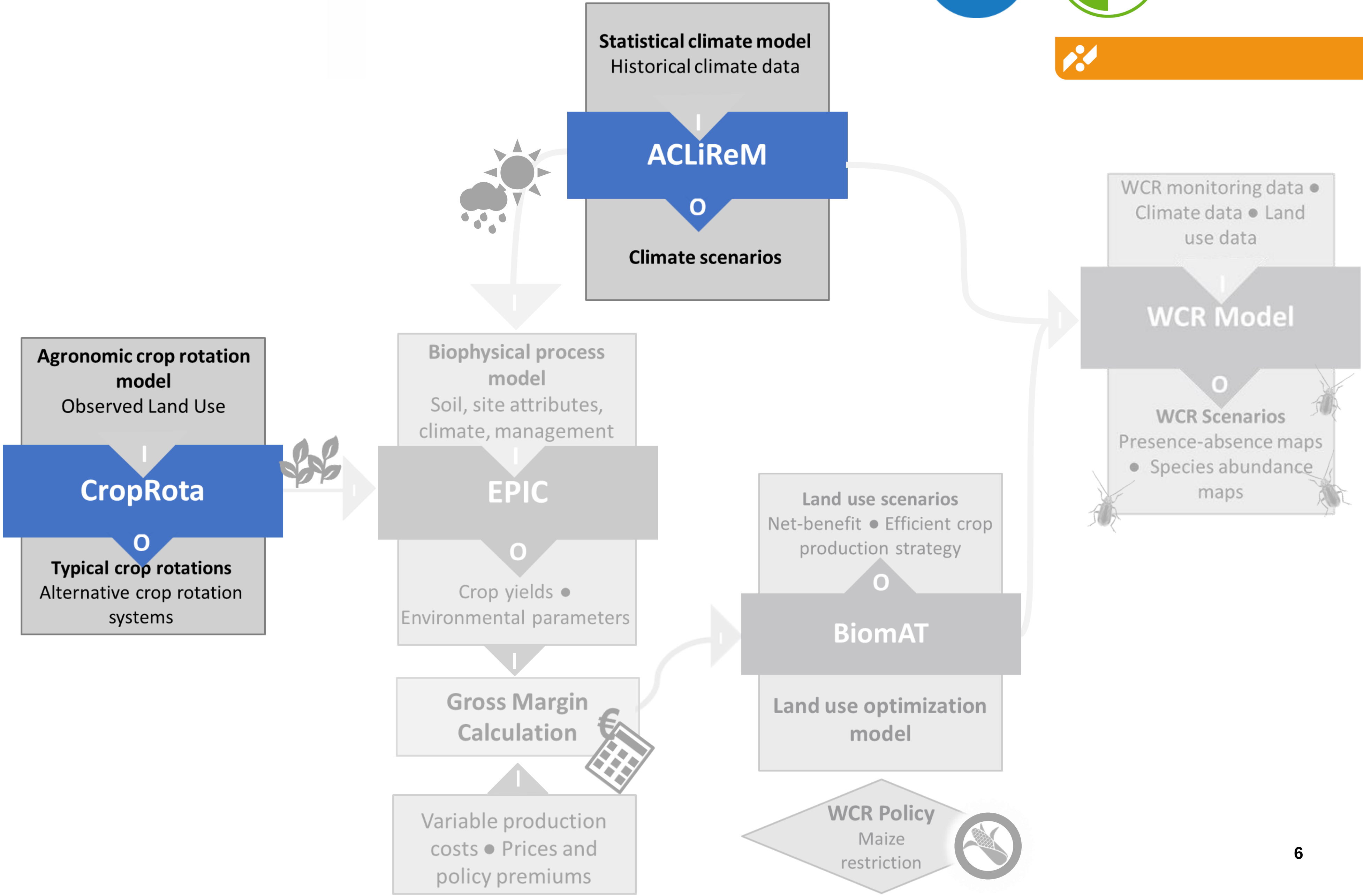
Model design

- development and calibration of a WCR abundance model
- application of the WCR model within an integrated modelling framework

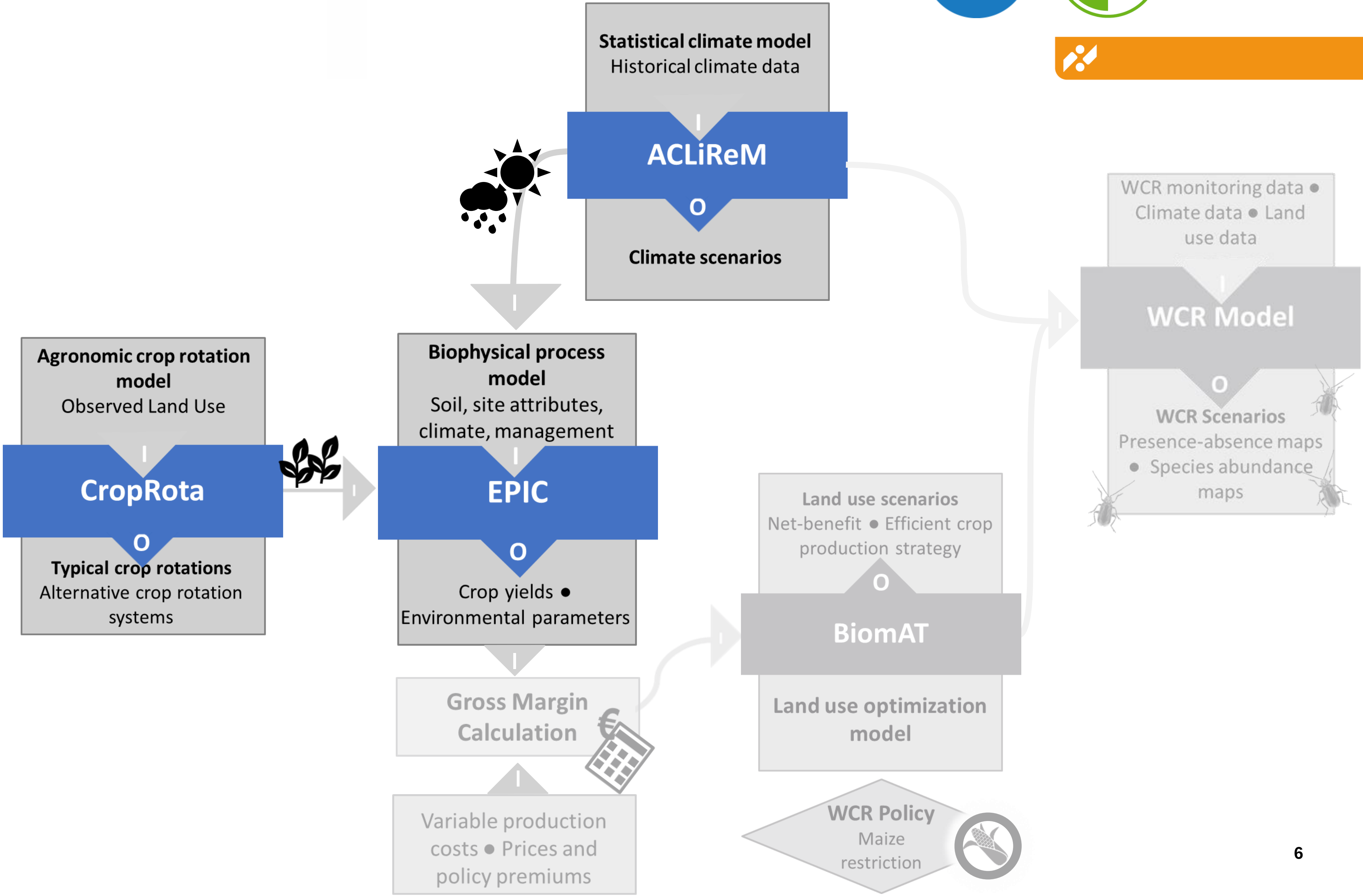
Integrated modelling framework



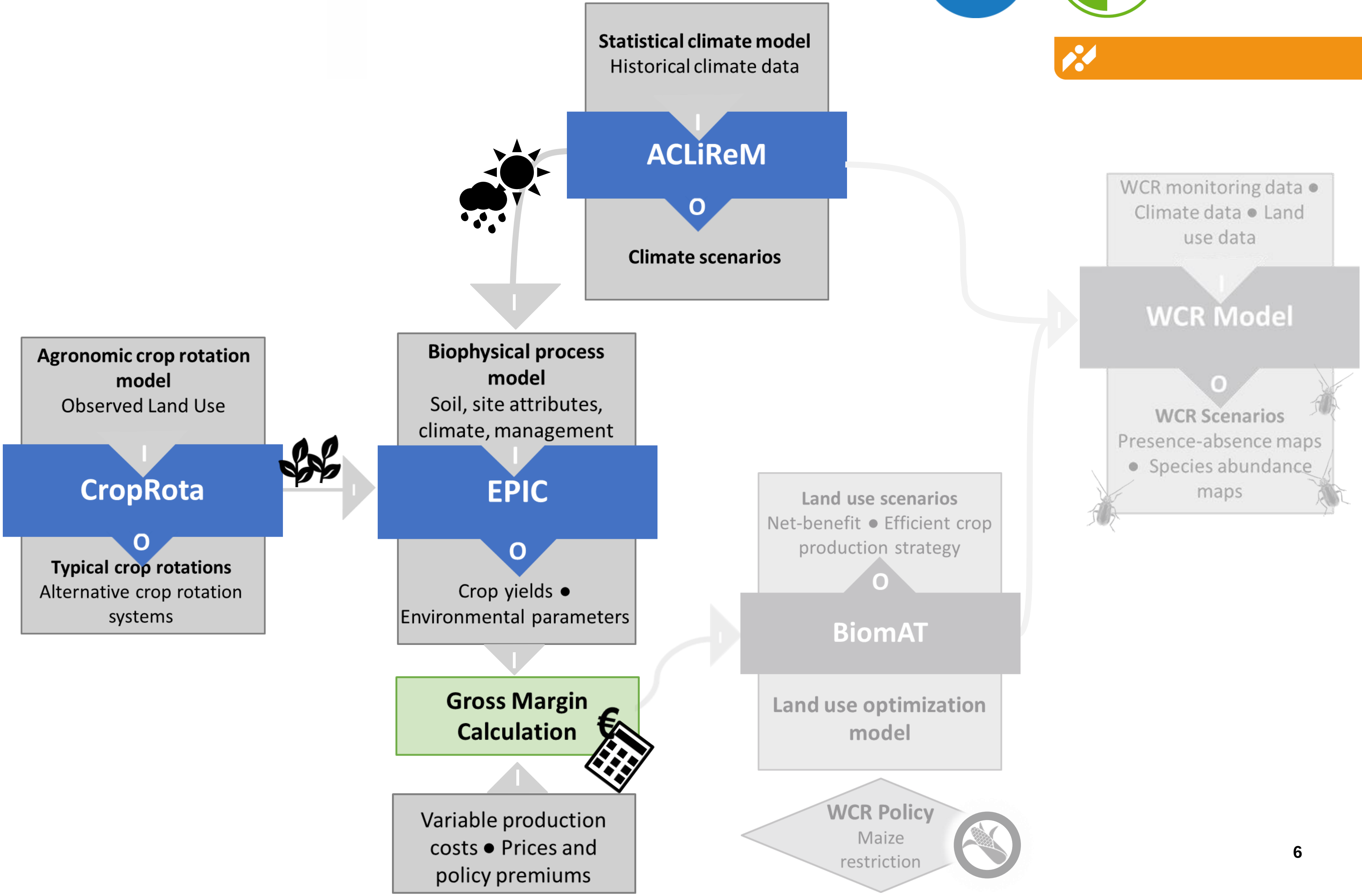
Integrated modelling framework



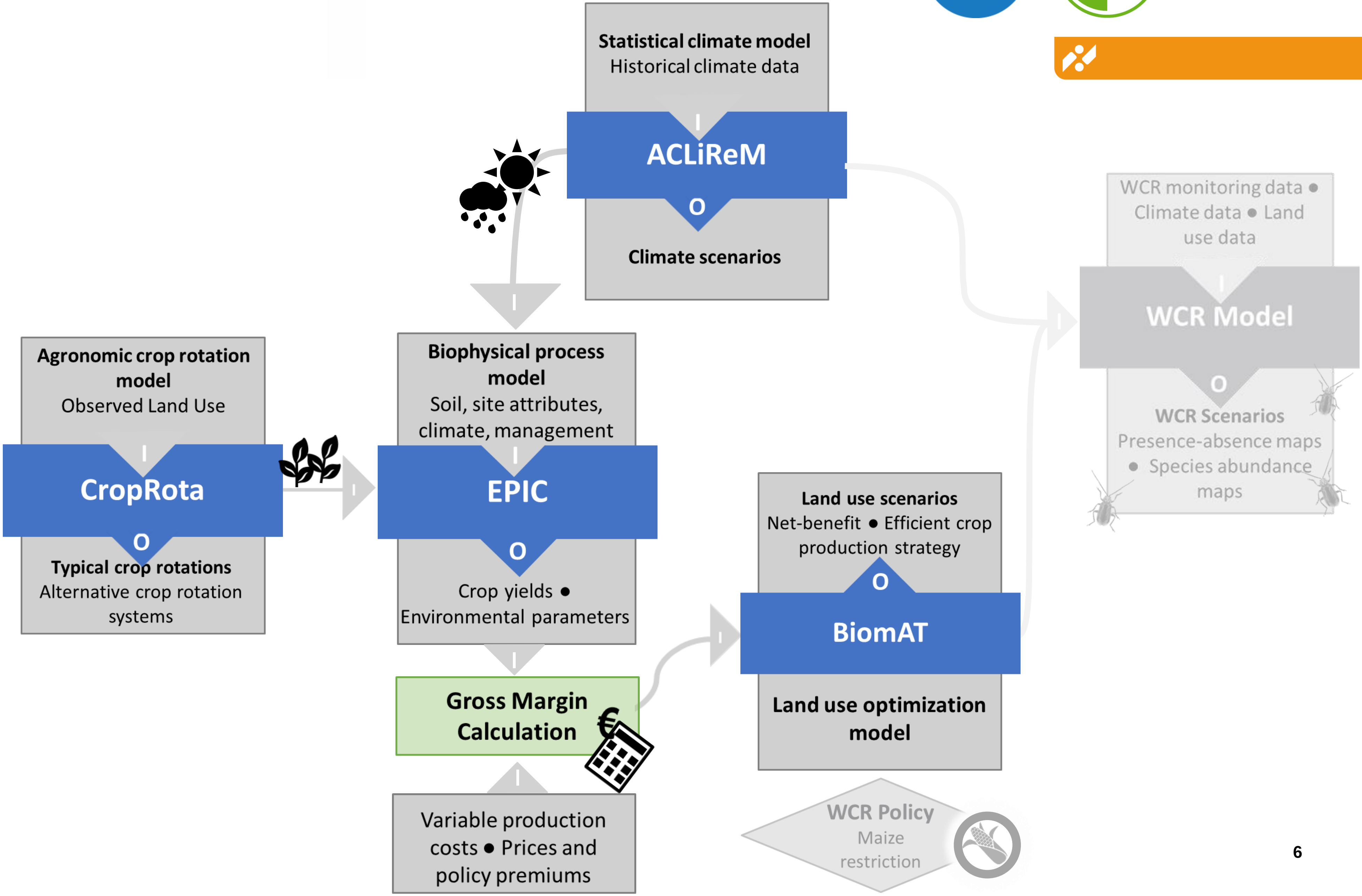
Integrated modelling framework



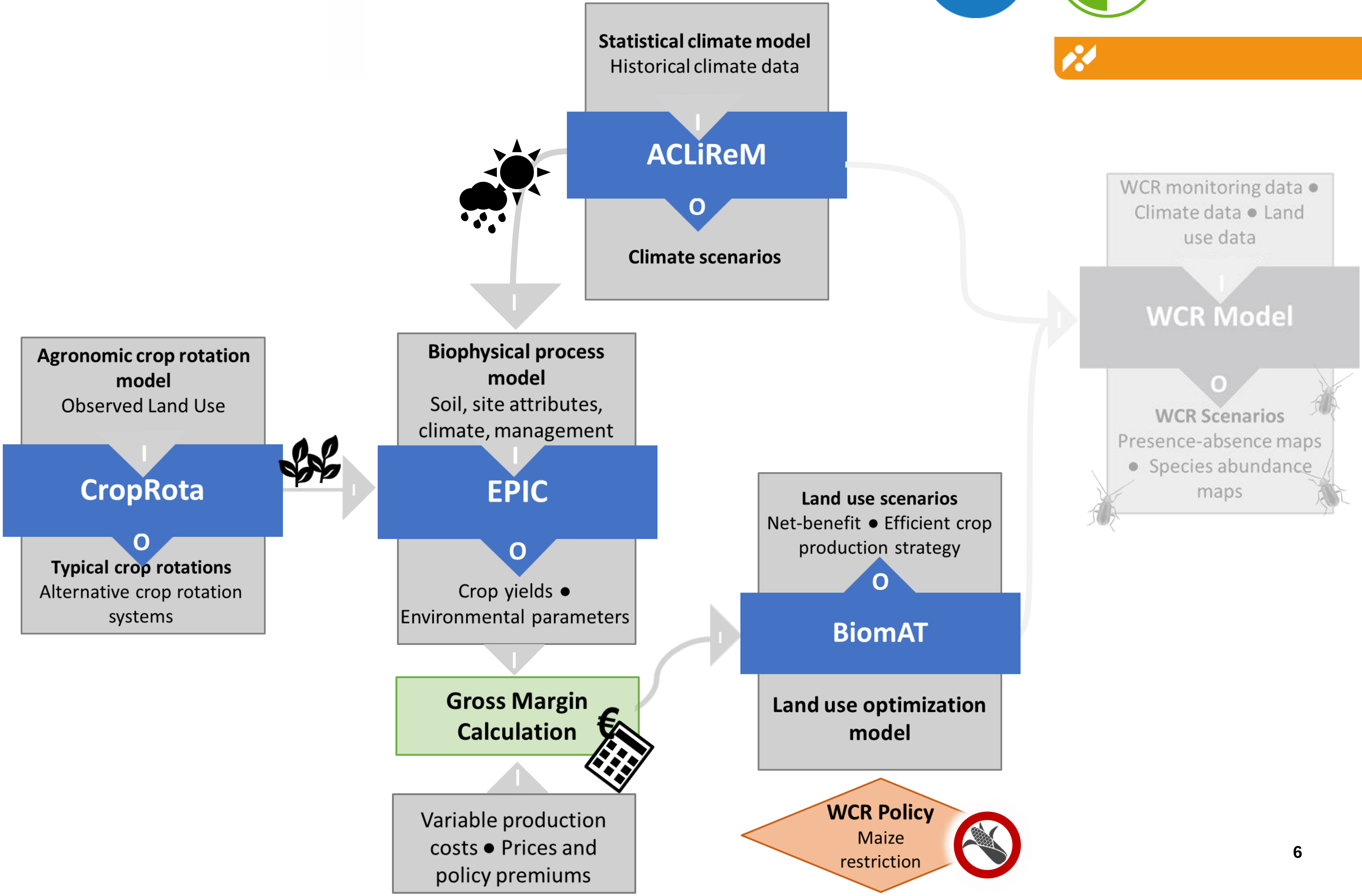
Integrated modelling framework



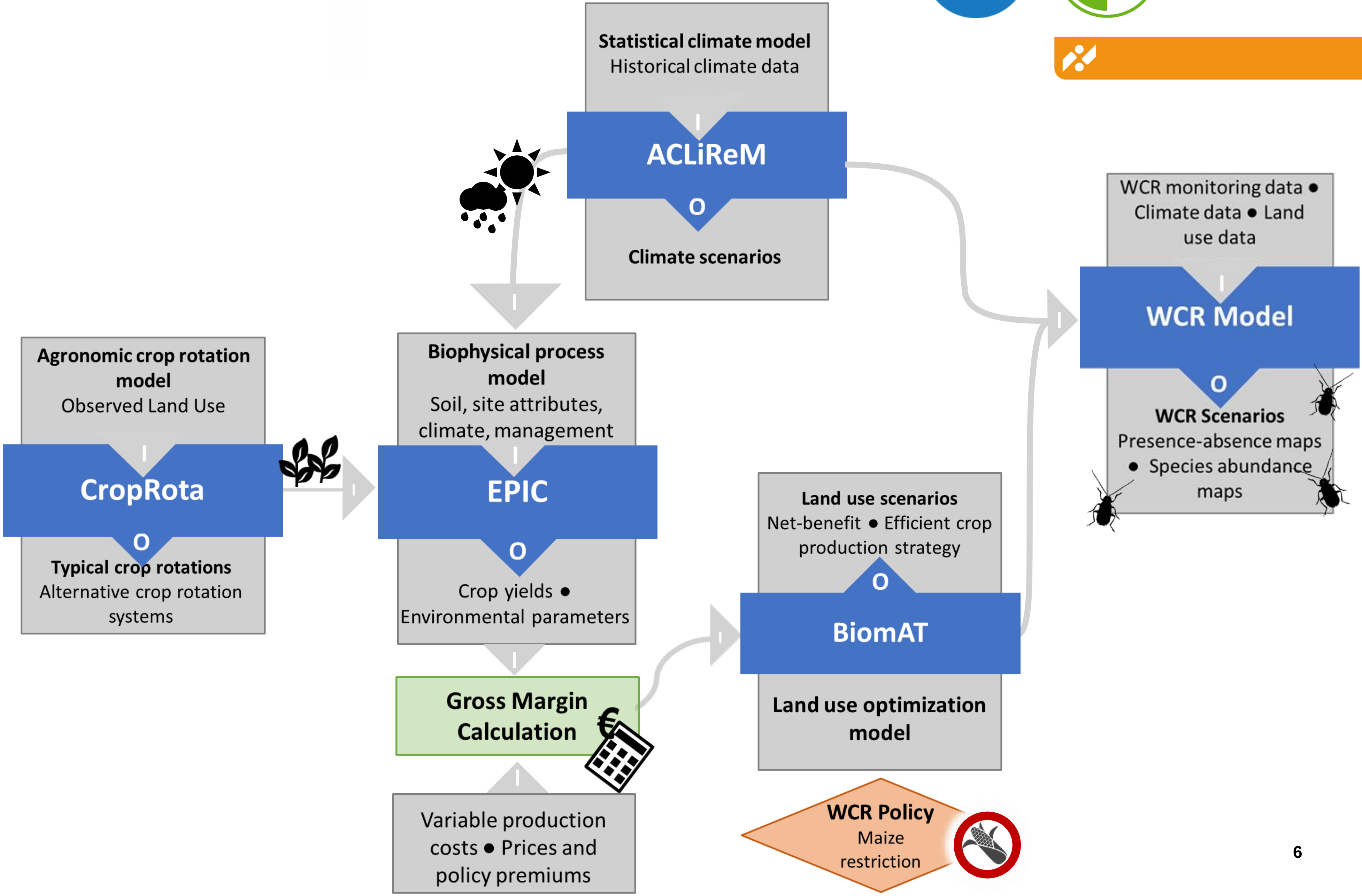
Integrated modelling framework



Integrated modelling framework



Integrated modelling framework



Assumptions and scenarios

Statistical climate model
Historical climate data

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O

Climate scenarios

Climate scenarios

Scenario	Temperature trend	Precipitation sums
SIMILAR	+ 0.05°C/year	resemble the past
WET	+ 0.05°C/year	increase (+20%)
DRY	+ 0.05°C/year	decrease (-20%)

Land use scenarios
Net-benefit ● Efficient crop production strategy

O

BiomAT

Land use optimization model

WCR Policy
Maize restriction

Crop rotation systems

Scenario	Upper limit for maize in crop rotations
BASE	unrestricted
MS50	50%
MS25	25%
MS10	10%

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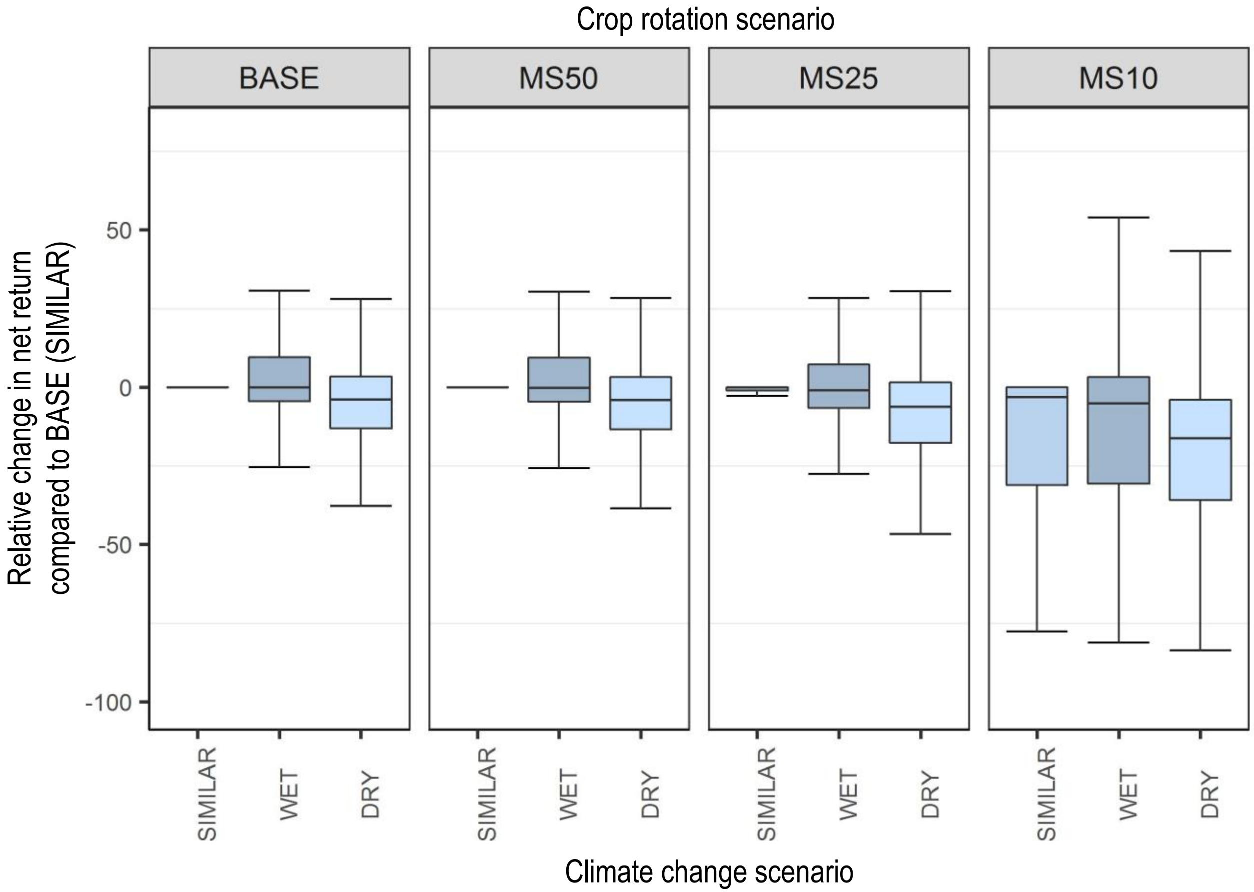
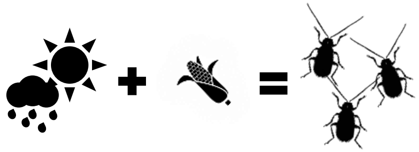
Economic effects

Changes in net returns by maize restrictions and climate change scenarios.



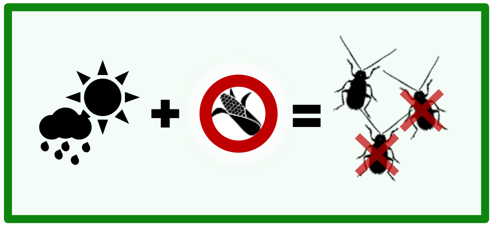
Source: own illustration based on model results.

WCR abundance

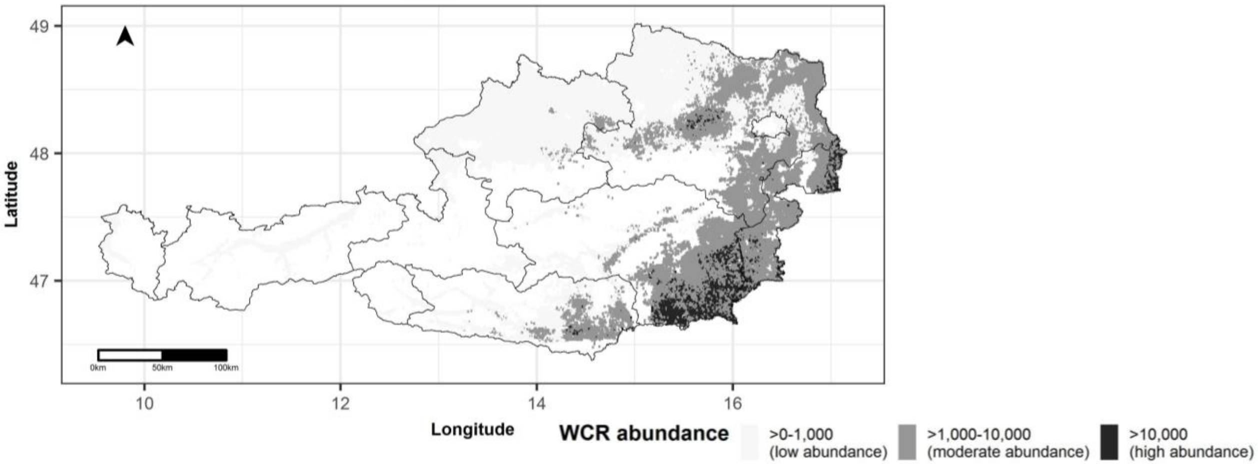


WCR control

→ Does WCR abundance decrease under crop rotation systems MS50, MS25 and MS10?

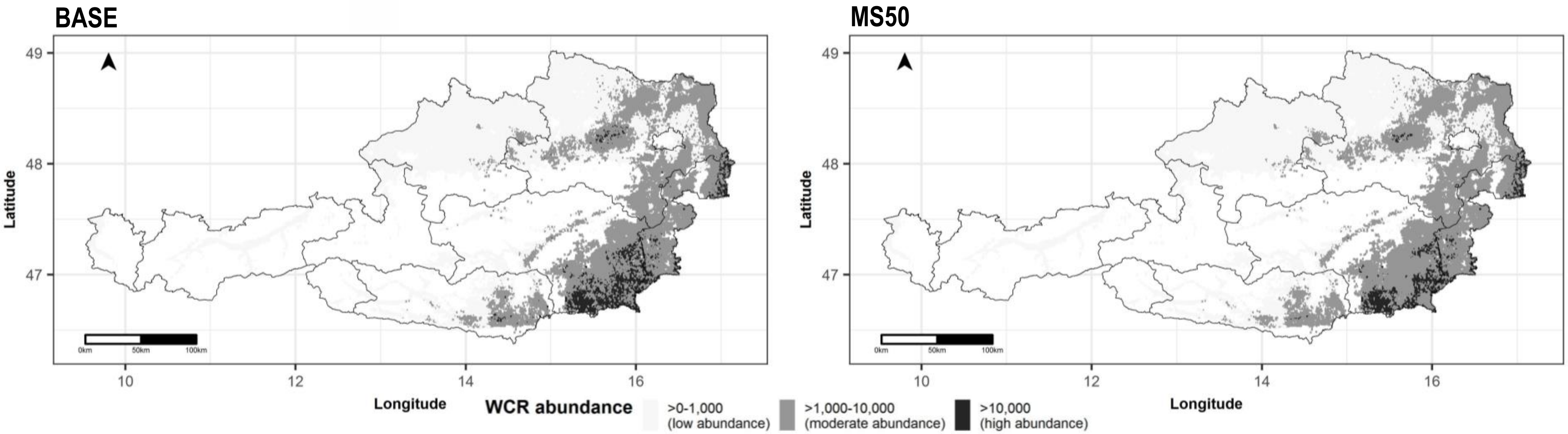


BASE



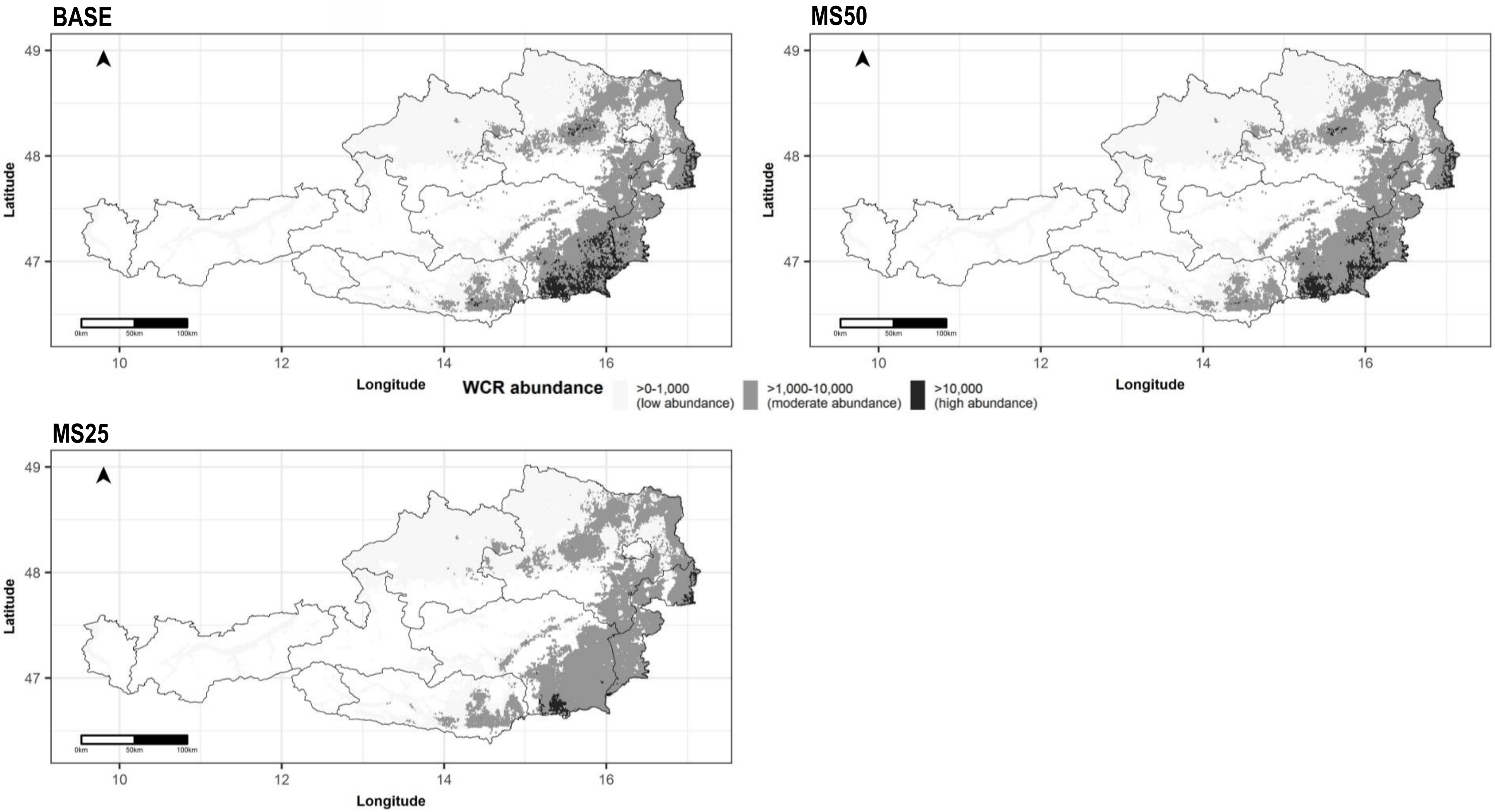
	SIMILAR		WET		DRY	
Crop rotation system	**High abundance** [ha cropland]	**Change in high abundance** [%]	**High abundance** [ha cropland]	**Change in high abundance** [%]	**High abundance** [ha cropland]	**Change in high abundance** [%]
REF	**88,729**					
MS50						
MS25						
MS10						

Source: Own illustration and calculation based on model results.



	SIMILAR		WET		DRY	
Crop rotation system	**High abundance** [ha cropland]	**Change in high abundance** [%]	**High abundance** [ha cropland]	**Change in high abundance** [%]	**High abundance** [ha cropland]	**Change in high abundance** [%]
REF	88,729		106,036	+19.5%	69,047	-22.2%
MS50	**63,945**	**-27.9%**	**88,475**	**-0.3%**	**47,074**	**-46.9%**
MS25						
MS10						

Source: Own illustration and calculation based on model results.



Crop rotation system	SIMILAR		WET		DRY	
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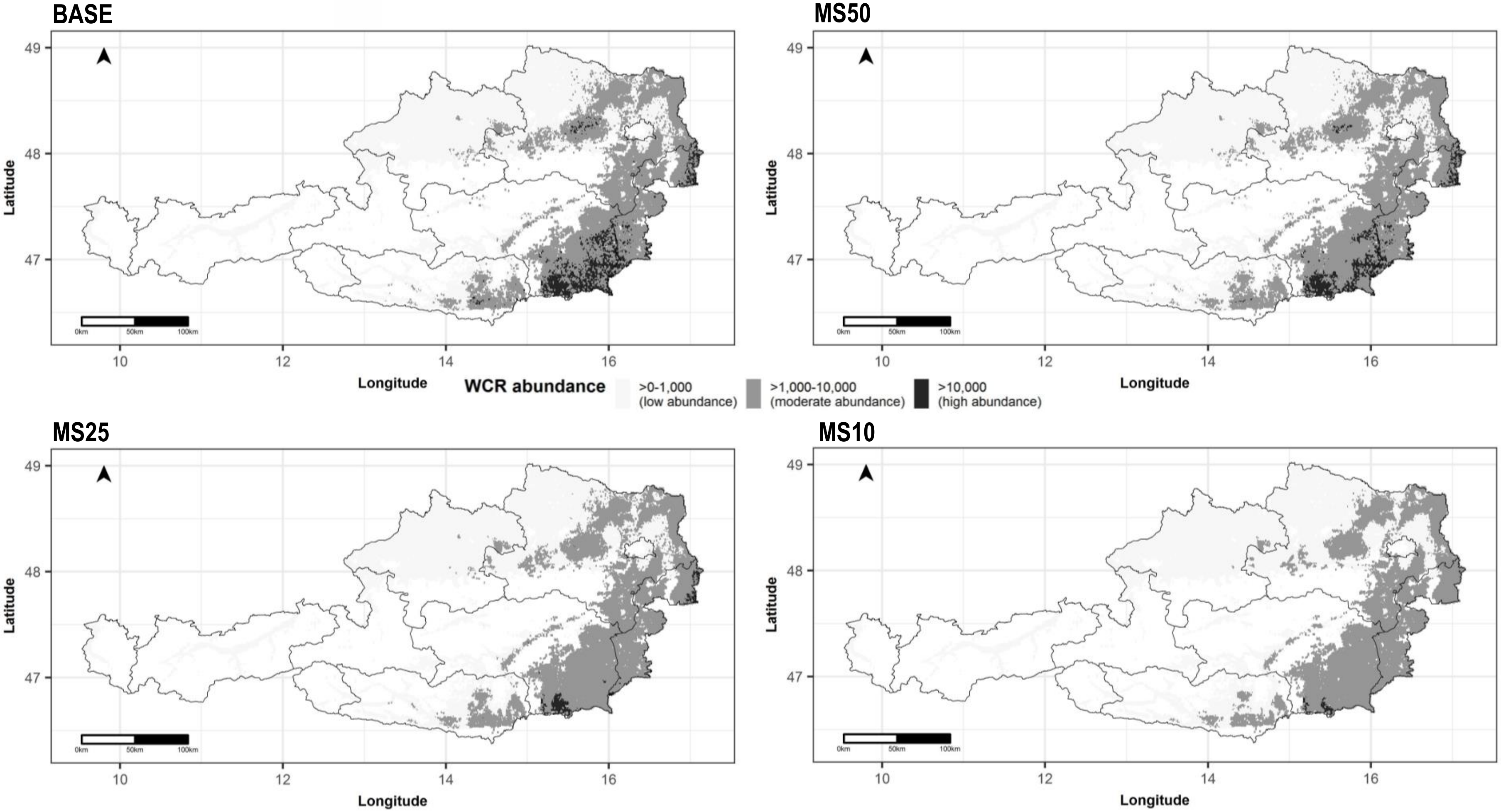
MS25	**14,829**	**-82.2%**	**26,519**	**-70.1%**	**6,867**	**-92.3%**
MS10						

Source: Own illustration and calculation based on model results.



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MS10	**1,404**	**-98.4%**	**3,258**	**-96.3%**	**278**	**-99.7%**

Source: Own illustration and calculation based on model results.

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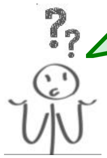
Conclusions

- Farmers are increasingly aware of risks resulting from pests and climate change.

  → Important to develop robust cropping systems and adequate policies to slow down pest dispersal rates

- The integrated modelling framework allows us to analyse the effect of
  - management strategies (i.e. crop rotation decisions) and
  - climate change

  on the risk of WCR infestation.



How does your model/method represent land use decisions?

Land use scenarios ≙ Land use decisions

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Conclusions

- Austrian maize production supplies
  - food
  - fodder
  - biofuels
- Crop rotation regulations with upper limits for maize can help to reduce WCR pressure.
  - ➔ Important to consider regional production characteristics.
    e.g. livestock farms highly dependent on maize
  - ➔ Farm and region specific analysis of the effects are important.

What are the main links between land use and ecosystem services outcomes?

→ maize production = provisioning services

→ WCR model & policies = maintenance and regulating service

What role do agricultural systems play in your model?

→ agricultural production systems = central

→ intensification/intensive agricultural production = important for WCR damages

→ Can a change in the agricultural system (away from intensive production) be a solution?

→ Evaluating the trade-offs between crop rotation regulations, economic effects and the risk of WCR infestation.

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Thank you for your attention!

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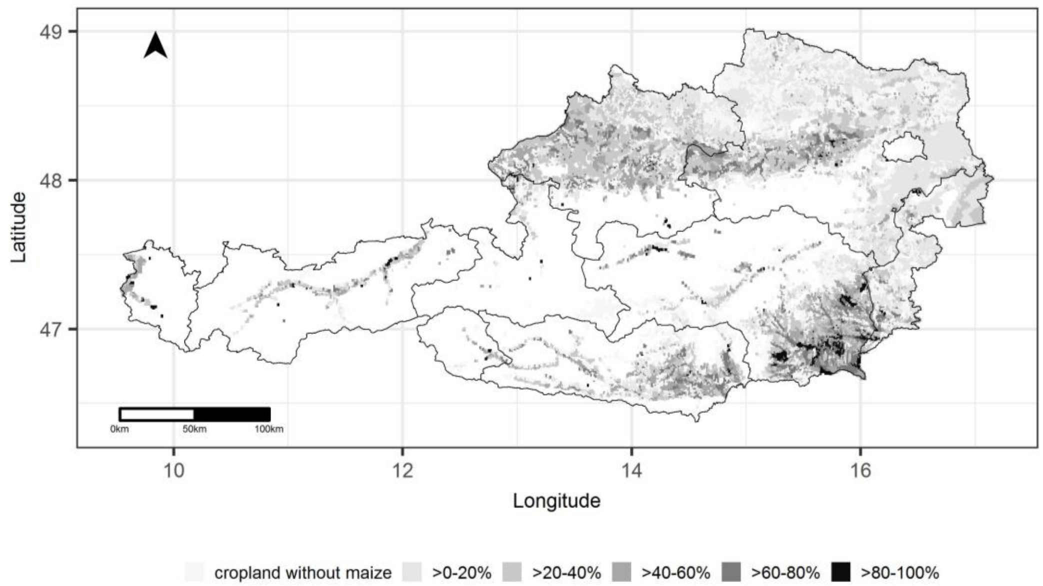
Research background

Maize production in Austria

- favourable cropping conditions: high yield potential, low labour input
- on 280.000 ha cropland
- maize production hotspots: south-east Austria (Styria, Burgenland), Northern Alpine Foothills (Lower Austria) → hotspots for WCR infestation



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WCR Model

- Zero-inflated Poisson mixture (ZIP) Model
  - account for the zero-inflation of WCR monitoring data
  - regression model, that combines
    - a Bernoulli model: Probability of WCR occurrence
    - a Poisson model: WCR abundance
- Kriging
  - interpolation method → estimations for total Austrian cropland
  - account for spatial autocorrelation
- Model validation
  - separate run for all monitoring years
  - cross validation
  - discussion with experts

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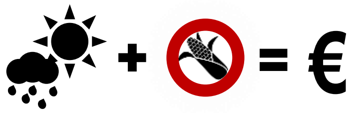
WCR Model

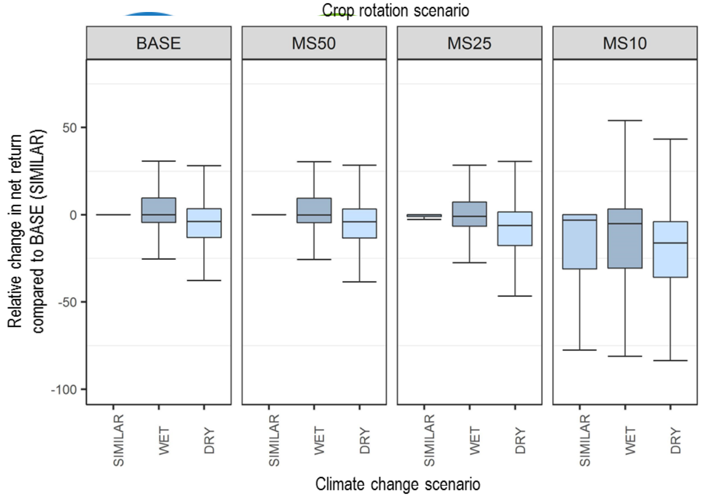
Influencing factors in the regression model

Factor	Description	Bernoulli model	Poisson model
Natural spread	Latitude and longitude of trap locations	✓	✓
Crop rotation	Locations specific maize shares on cropland per municipality	✓*	✓
Climate parameters	• Mean temperature in winter (Nov. – Feb.)		✓
	• Mean temperature in summer (June – Aug.)		✓
	• Temperature maximum in the hottest months (July – Aug.)		✓
	• Precipitation sums in summer (June – Aug.)		✓

* included in the calculation from 10% onwards (Assumption: Minimum necessary for WCR survival)

Economic effects

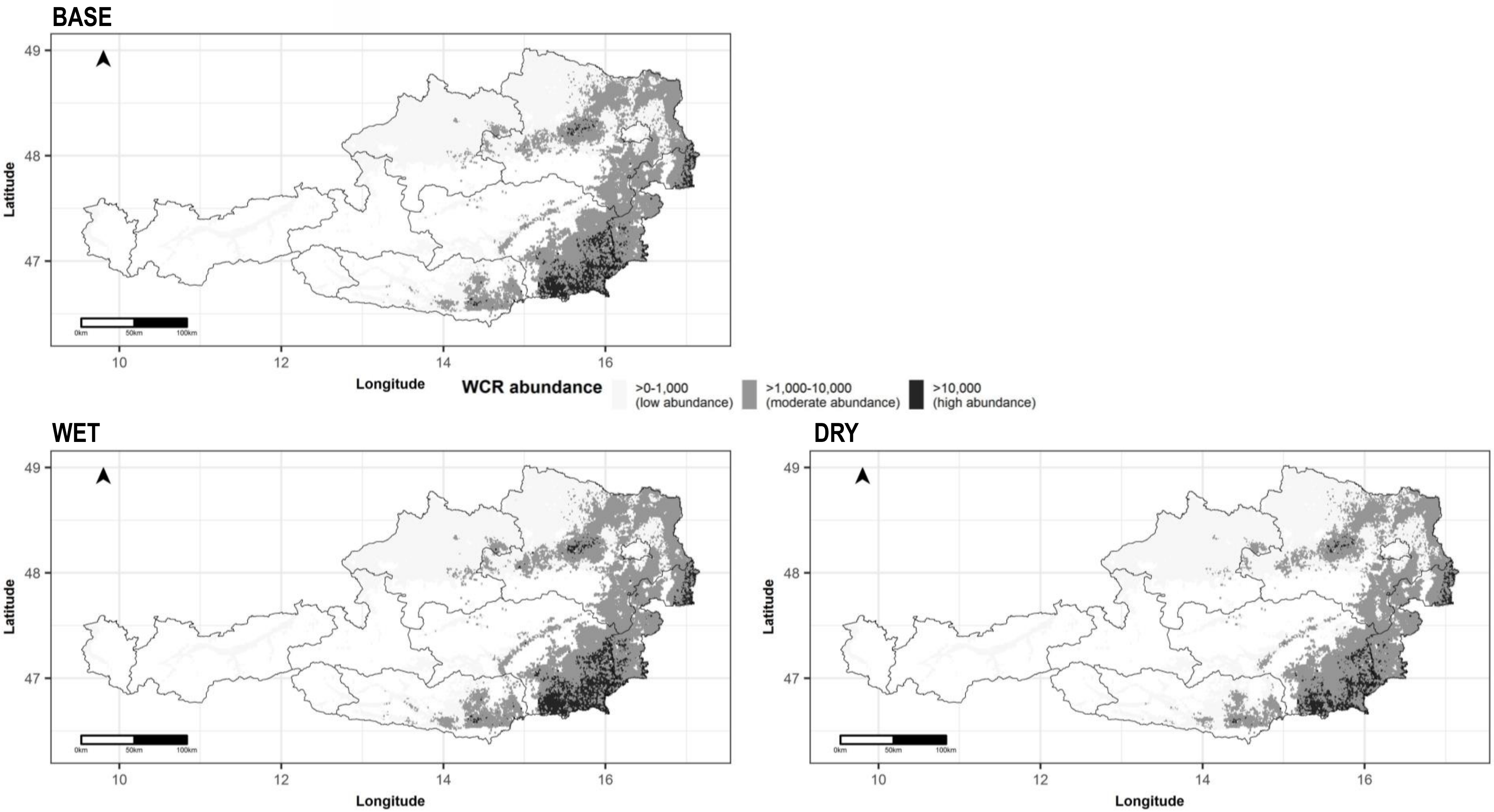




Changes in net returns by maize restriction and climate change scenarios.

- Compared to BASE, net returns
  - show a decreasing trend, if maize production is limited to MS50, MS25 or MS10
  - are highest under WET and lowest under DRY climatic conditions
  - decrease most under most restrictive limits for maize in crop rotations
  - show a higher spatial variability
- Decreasing net returns
  - are the result of the combined effect of changed crop sequences and climatic conditions
  - ⇨ costs for insecticide application and yield losses from WCR infestation are not considered
- Feusthuber et al. (2017) show that yield losses from WCR damages can considerably reduce net returns.

WCR abundance – climate effect



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MS50						
MS25						
MS10						

Source: Own illustration and calculation based on model results.

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Relevant literature

- Feusthuber, E., Mitter, H., Schönhart, M., Schmid, E., 2017. Integrated modelling of efficient crop rotation management strategies in response to economic damage potentials of Western Corn Rootworm in Austria. Agric. Syst. 157, 93–106. https://doi.org/10.1016/j.agsy.2017.07.011.
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