

# Across Disciplines and Across Scales

## Introduction of Challenges

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<http://www.lap.uni-bonn.de>

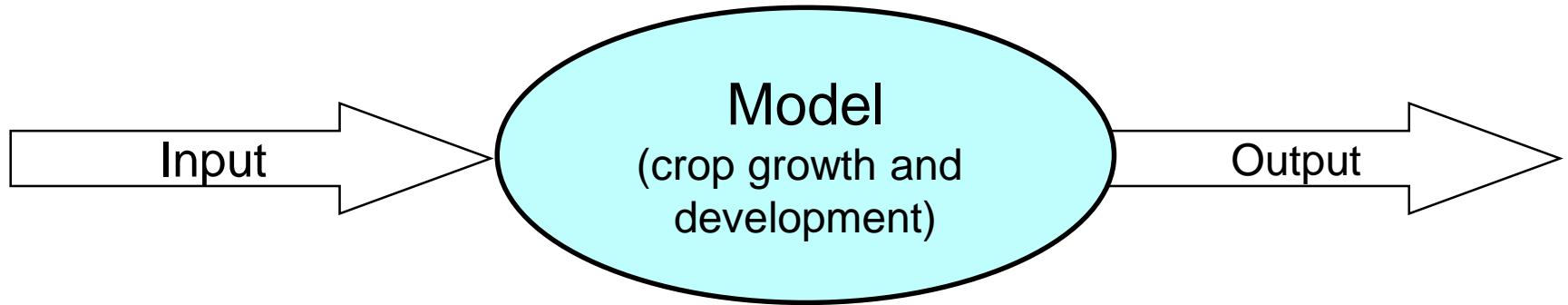


*AgMIP, Agriculture, Climate Change and Food Security, 13-18 September 2015, Aspen*

# Background

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Model (crop)



Sources of uncertainty

## Input data

- Climate, soil, management
- Genetic characteristics

## Model

- Structure
- Parameters

## Output data

- Post processing
- Observations

# Background

Model linkage

Bio-physical

Socio-economic

Global

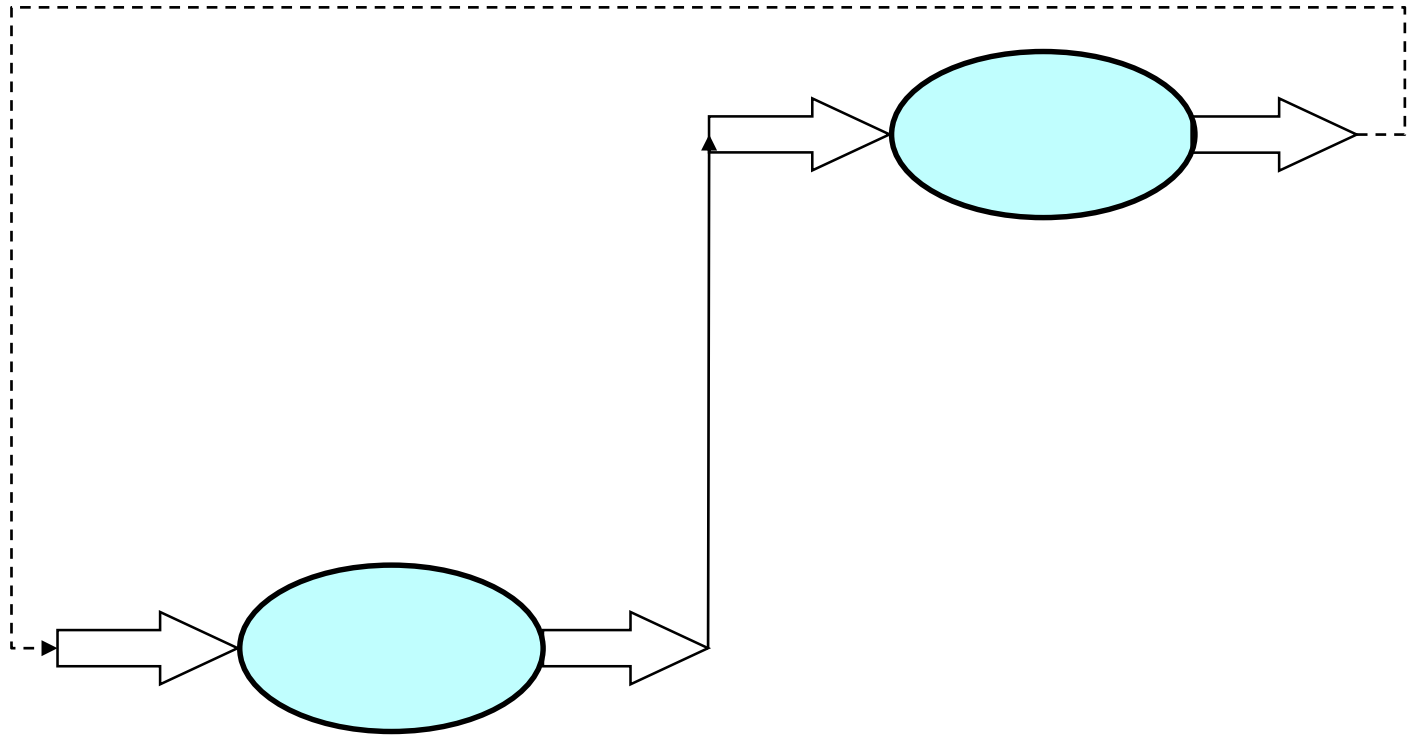
Continent

Regional

Farm

Field

...

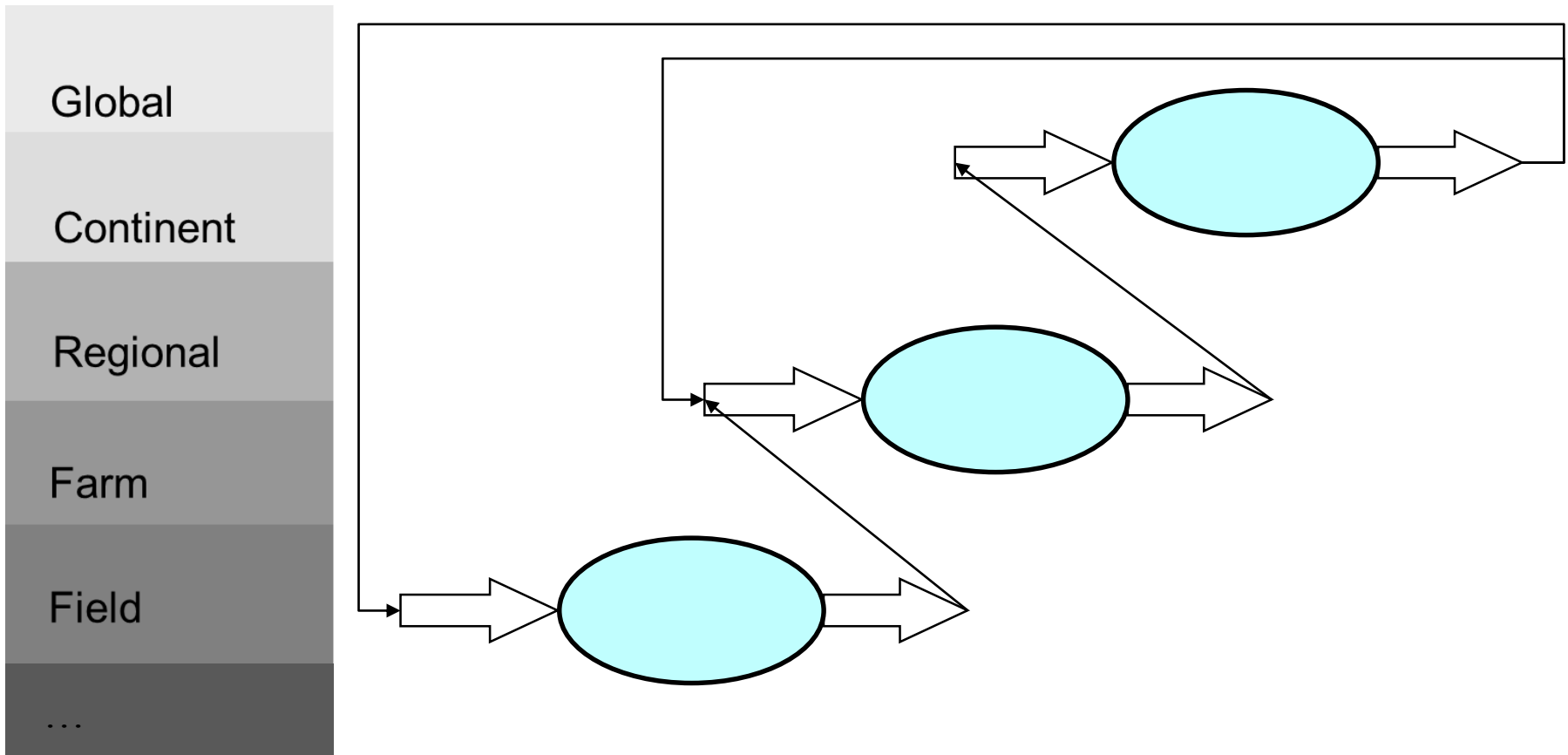


# Background

# Model linkage

# Bio-physical

## Socio-economic



# Background

## Terminology

**Extent/duration;** *boundaries area or magnitude*

**Resolution;** *finest detail that is distinguishable*

**Coverage;** *proportion of the area considered*

Scale refers to ...

physical dimensions (e.g. space and time)  
of observed entities and phenomena.

- Dimensions and units of measurement can be assigned
- Changes in scale are continuous

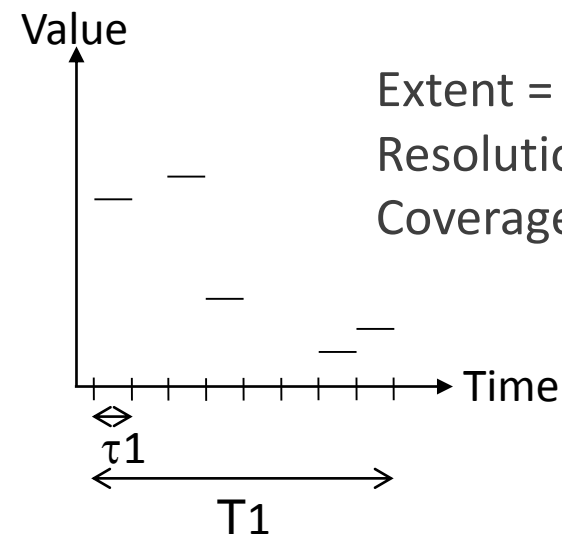
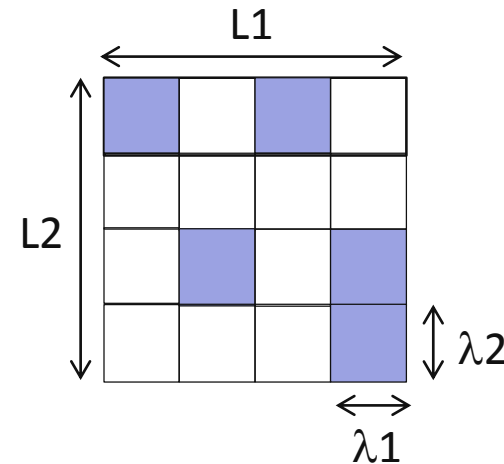
Level of organization in a hierarchically organised system.

- Changes in level are discrete
- Moving across levels may imply that spatial and temporal scales change

Extent =  $L1 \times L2$

Resolution =  $\lambda1 \times \lambda2$

Coverage =  $5/16$



Extent =  $T1$

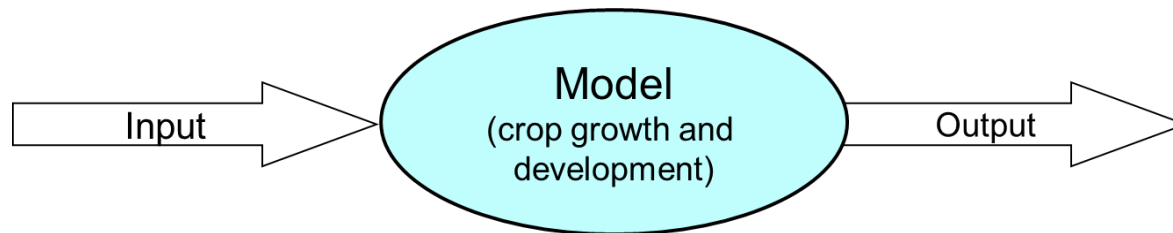
Resolution =  $\tau1$

Coverage =  $5/8$

# Background

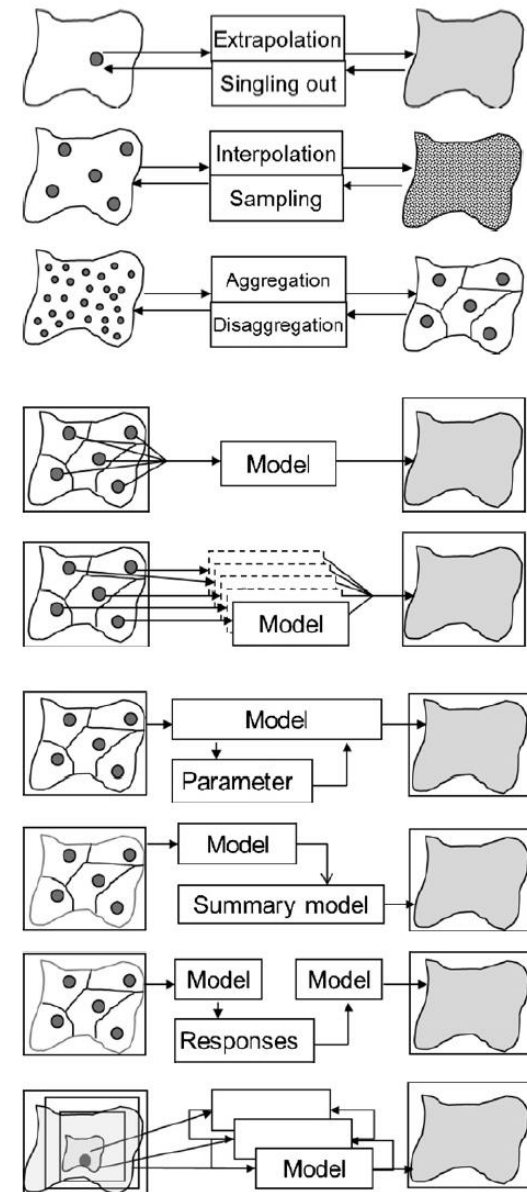
## Methods of up-scaling

Regional map of sun-induced fluorescence measured from an aircraft sensor (mature corn fields are selected), Rascher et al., 2009



Manipulation of :

- Model input/output data
- Model parameters
- Model structure

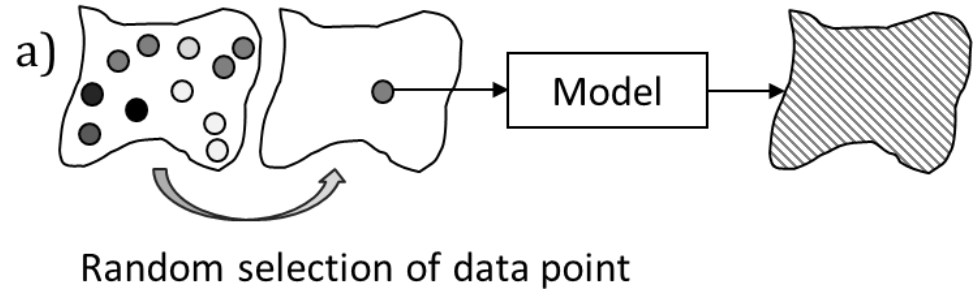


Ewert et al, 2011

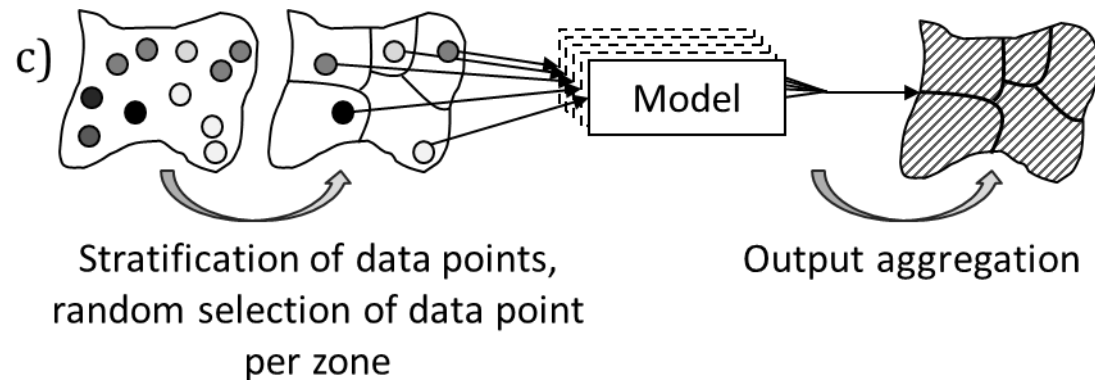
# Point vs. gridded

## Scaling of input data (2 methods)

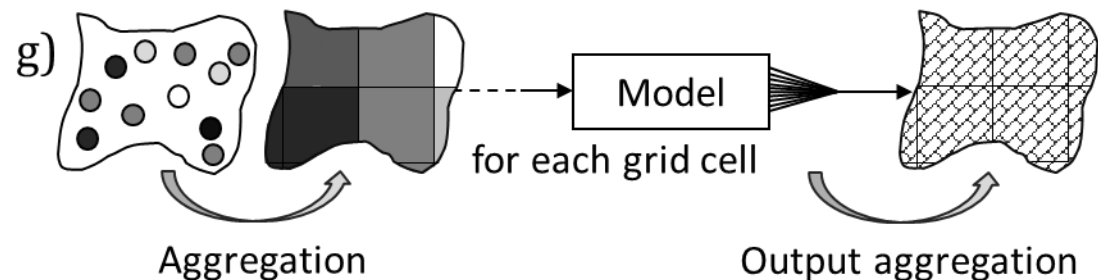
### Sampling (extrapolation)



### Stratified sampling

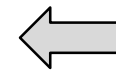
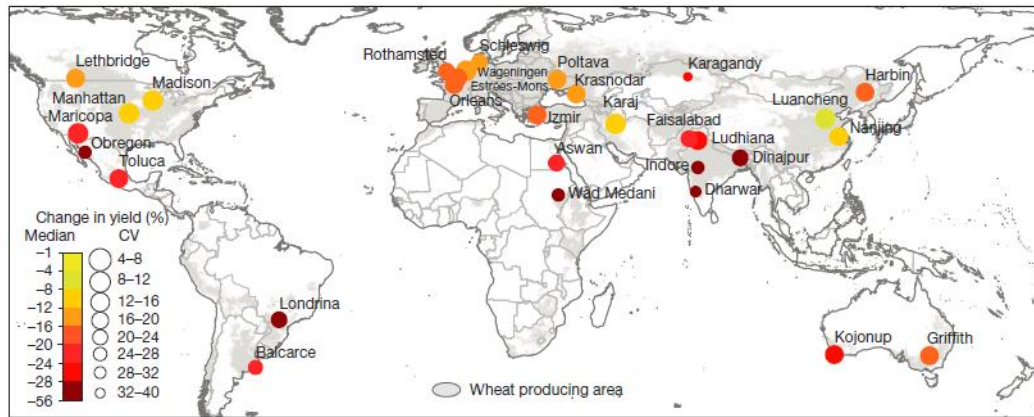
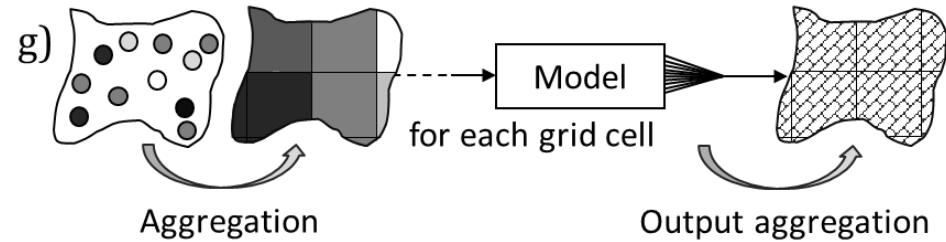
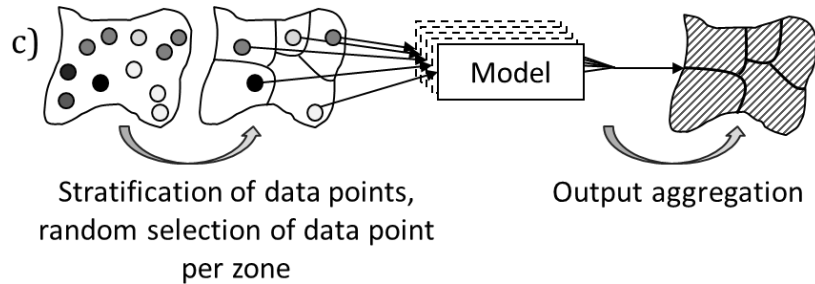


### Aggregation of input data





# Point vs. gridded

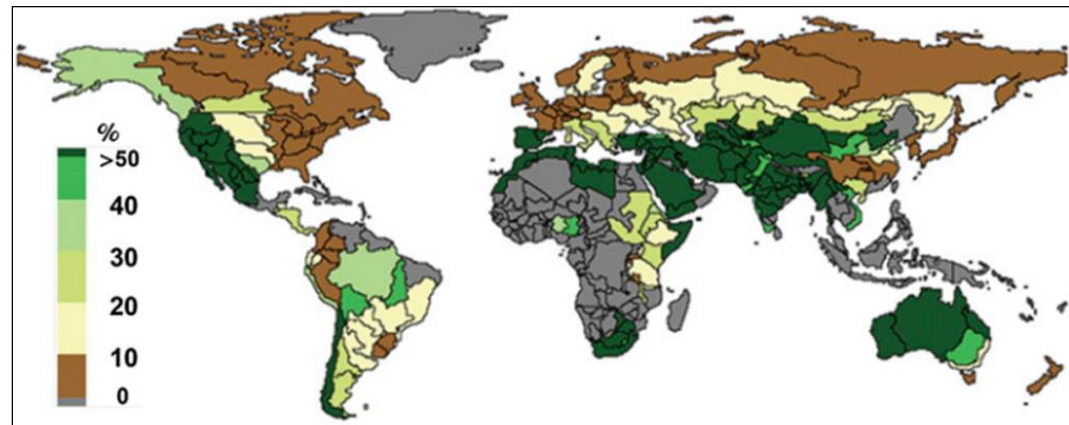
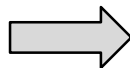


AgMIP-Wheat  
(Yield changes, 4°C)

Elliott, Deryng, Müller, et al, 2013

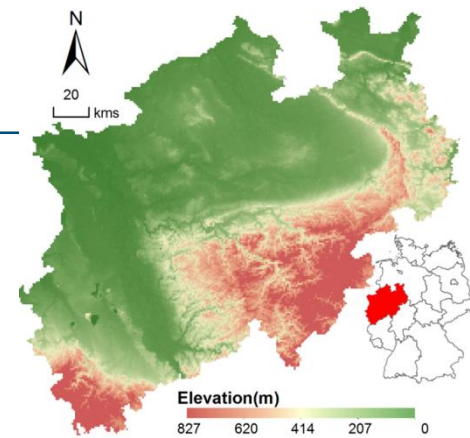
Asseng, Ewert, Martre, et al, 2015

AgGRID  
(Yield changes, with  
irrigation under CC)





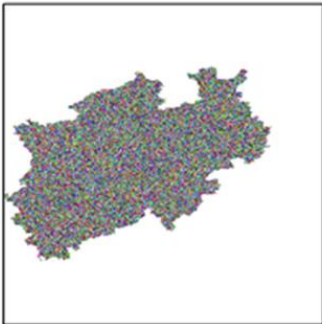
# Point vs. gridded



## Scaling of input data (2 methods)

- 2 crops (wheat, maize)
- grain yield, ET, ...
- > 12 models
- 3 production situations

a) High resolution data

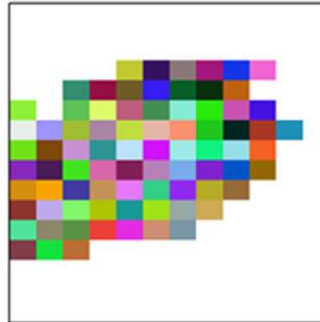


b) Changing size of grid cells

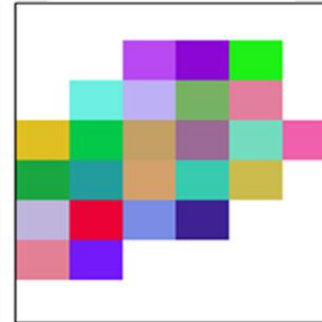
10 x 10 km<sup>2</sup>



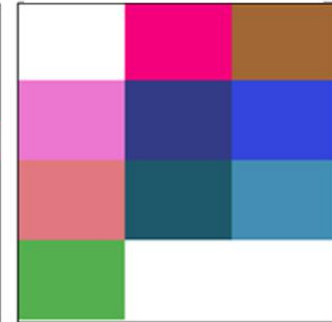
25 x 25 km<sup>2</sup>



50 x 50 km<sup>2</sup>

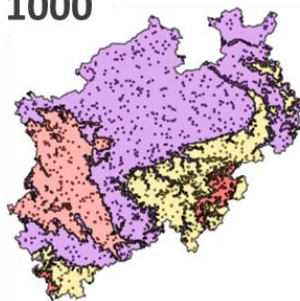


100 x 100 km<sup>2</sup>

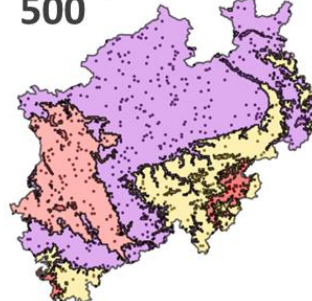


c) Changing size of sampling points

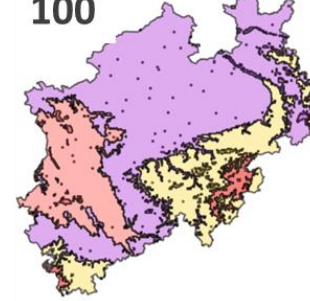
1000



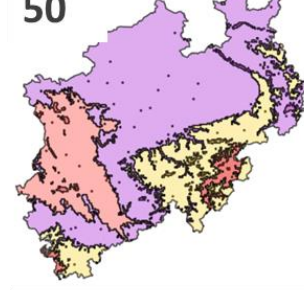
500



100



50



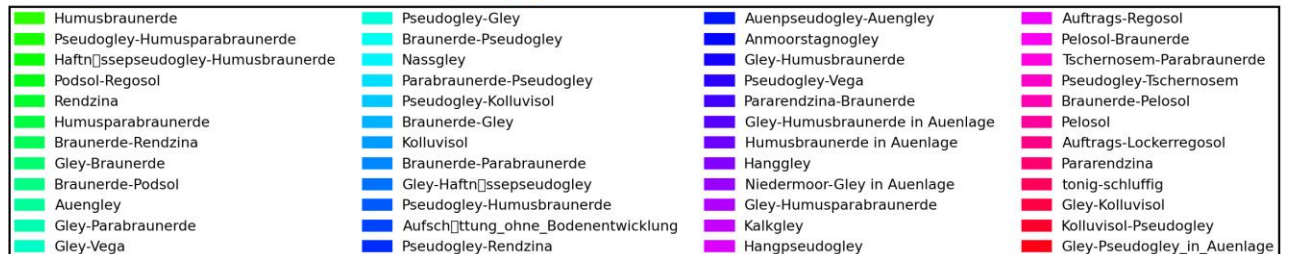
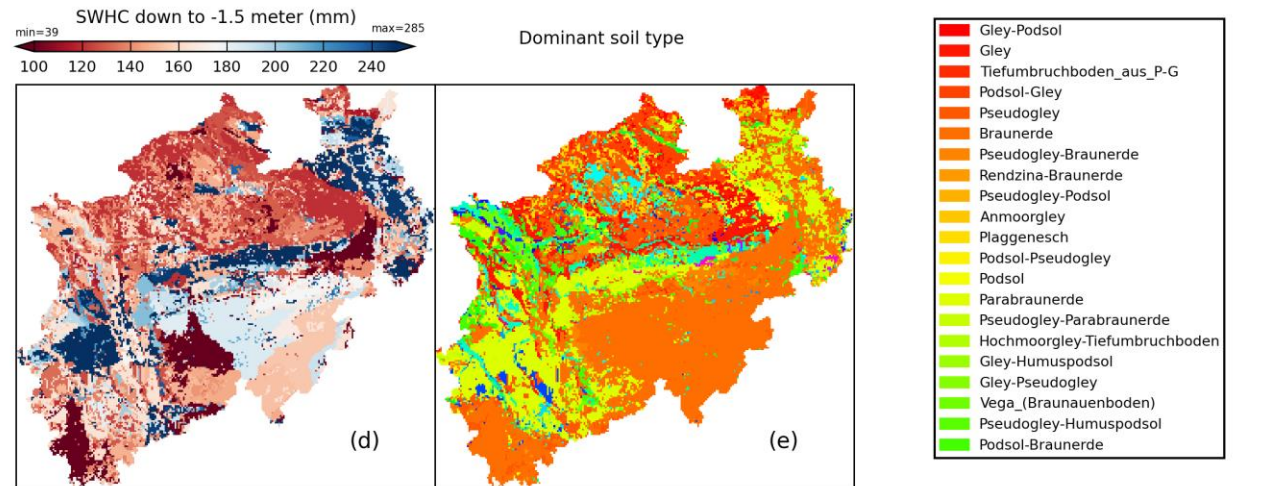
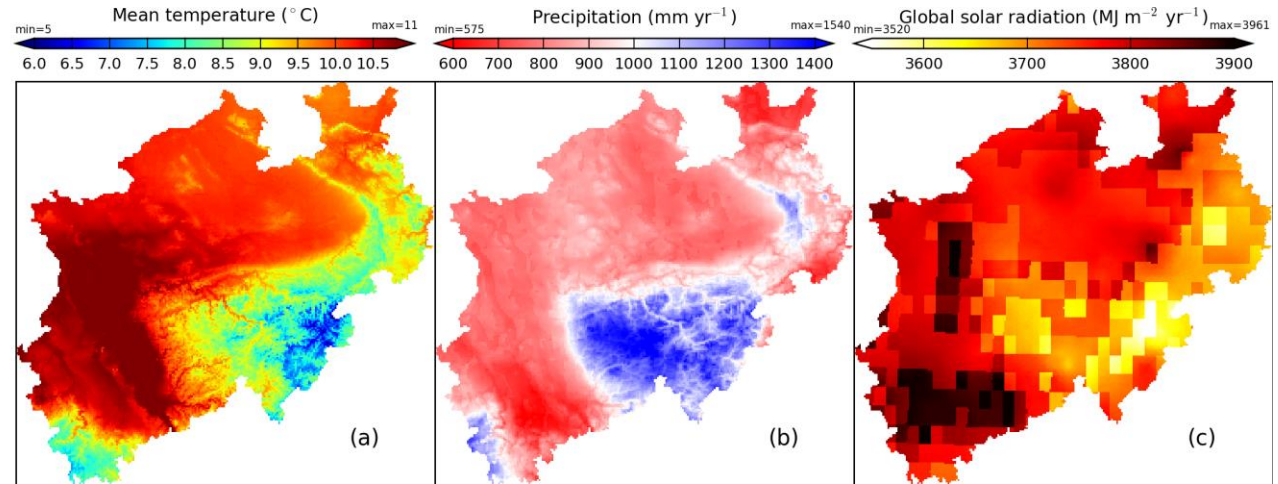
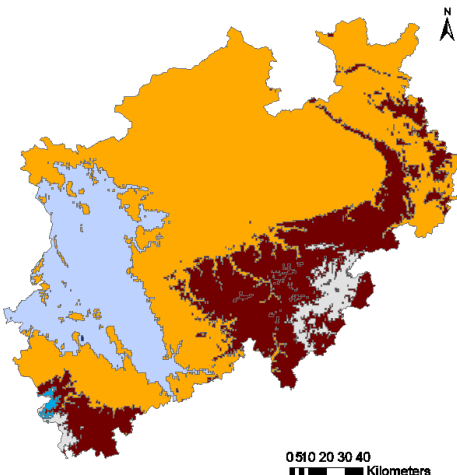
# Point vs. gridded

## Point vs. grid

Regional conditions:

- Temperatur
- Precipitation
- Radiation
- Soil water holding capacity
- Soil types

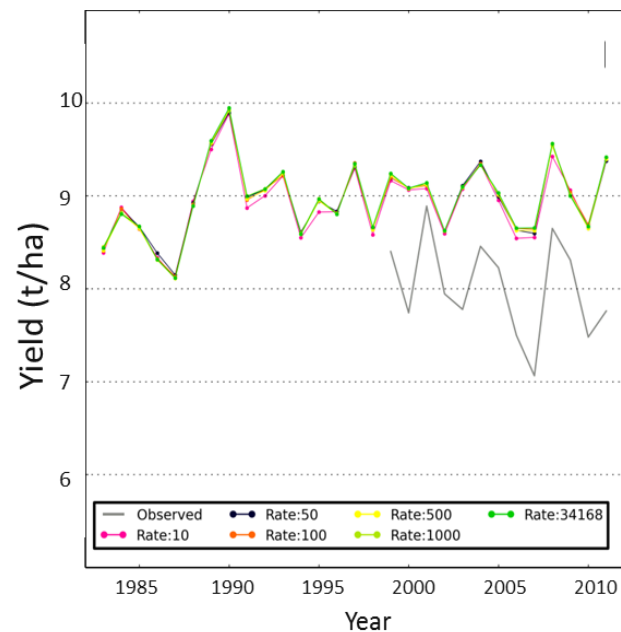
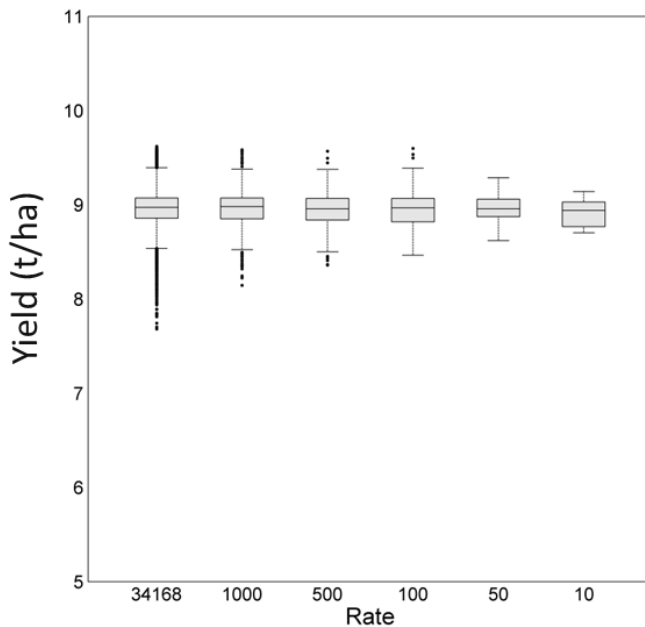
## Environmental stratification



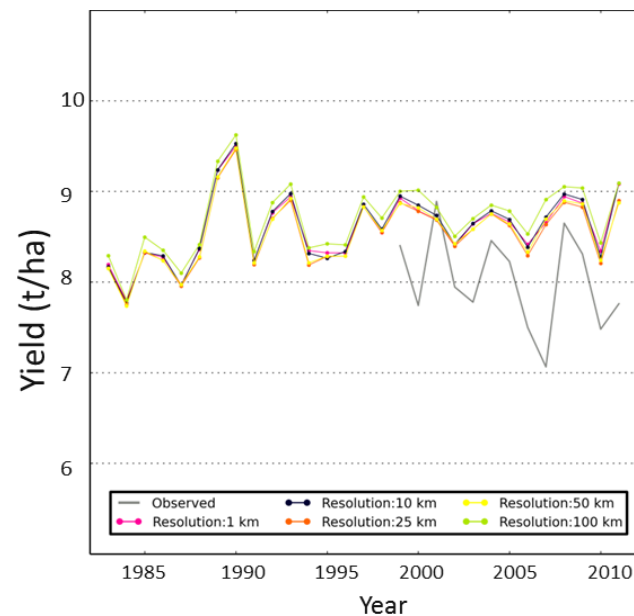
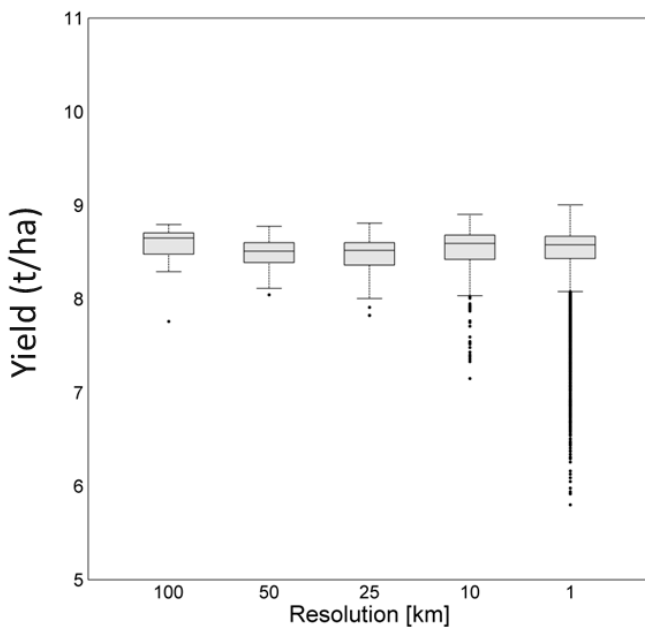
# Point vs. gridded

## Sampling points

- Wheat
- SIMPLACE
- <Lintul>



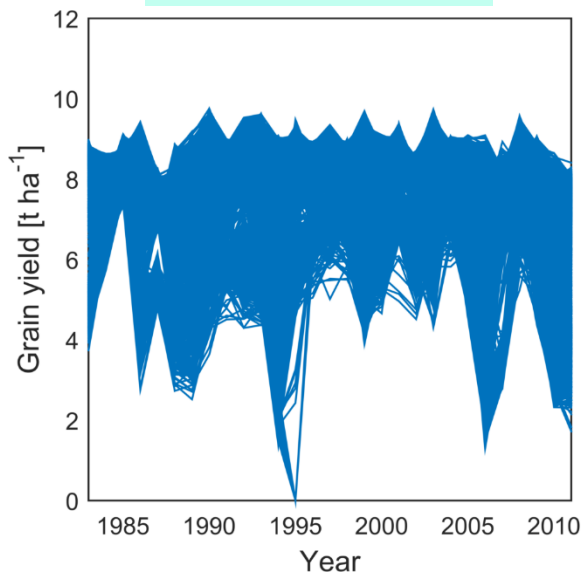
## Grid size



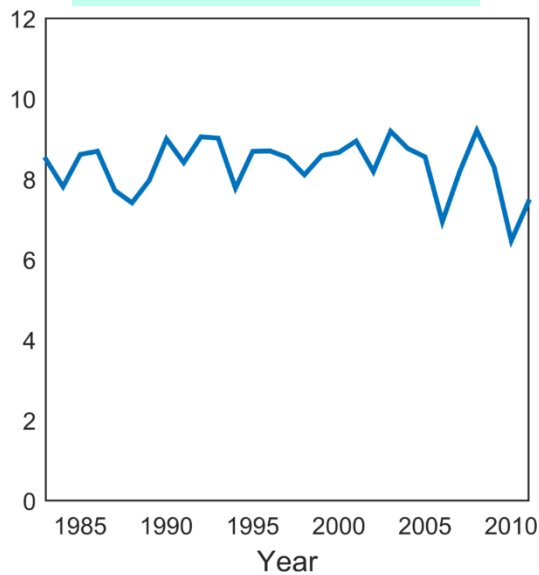
# Point vs. gridded

## Example wheat (grain yield)

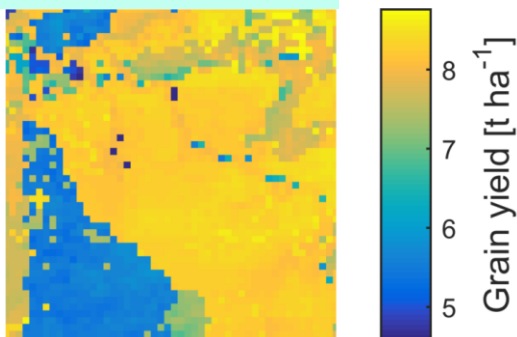
2500 points



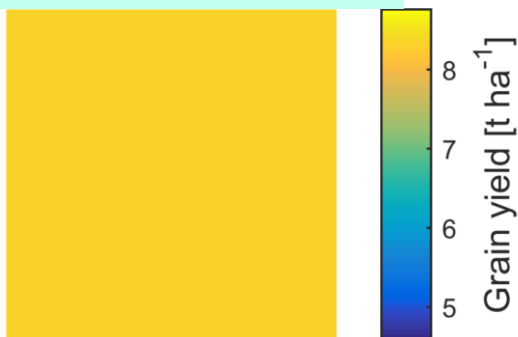
50 x 50 km grid



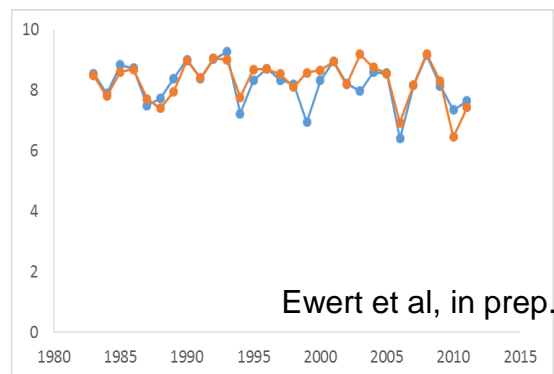
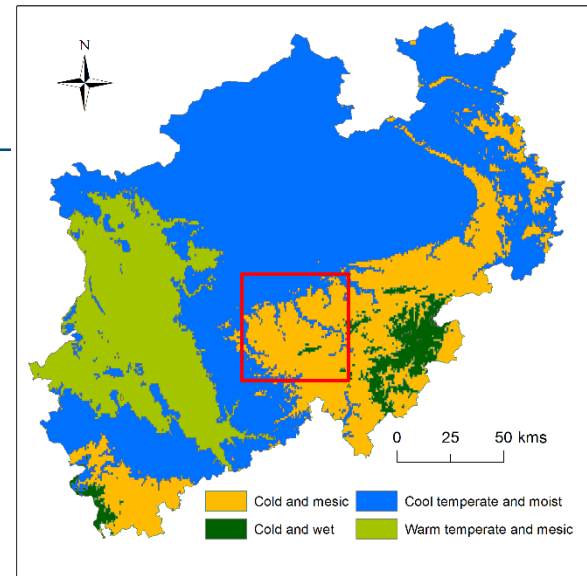
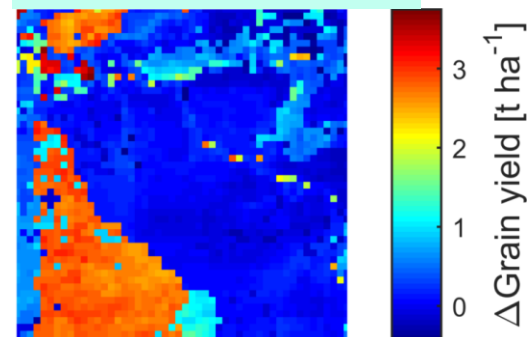
2500 points



50 x 50 km grid

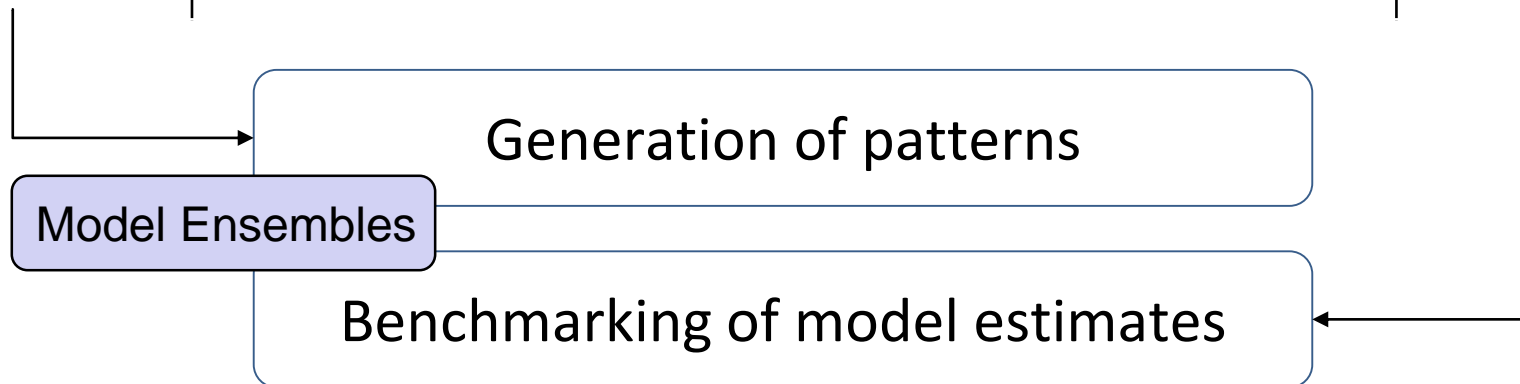


$\Delta$  Grid - point



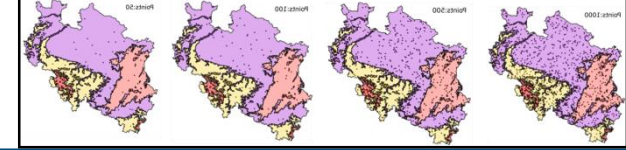
## Conclusions on point vs. gridded

Gridded	Aspect	Point
+	Coverage	-
-	State of model testing	+
-	Model parameterization	(+)
+	Standardized methods/protocols for IA	-
(+-)	Model relevance	+
(+)	Data quality (input data, testing, calibration)	+
-	Regional delineation	+





# Point vs. gridded

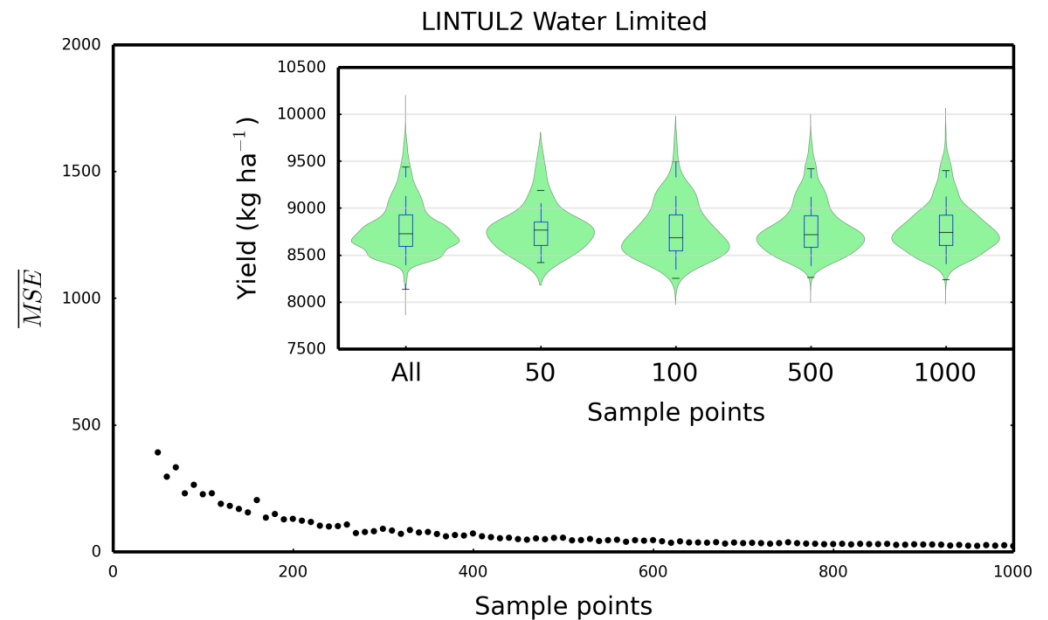
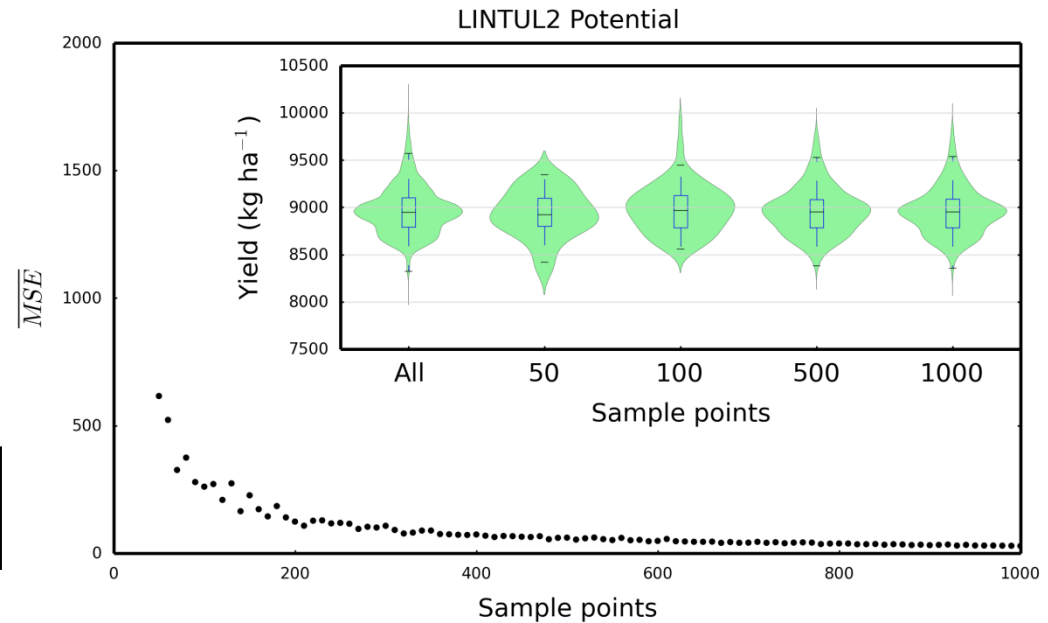


The results (effect of sampling),  
one model

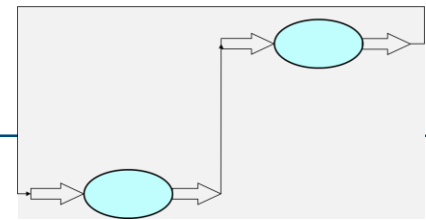
Expectation for MSE  $E(MSE)$

$$E(MSE_{n1,n2,n3,n4}) = bias(\hat{y}_t)^2 + \sum_{s=1}^4 w_s^2 \text{var}(\hat{y}_s^*) / n_s$$

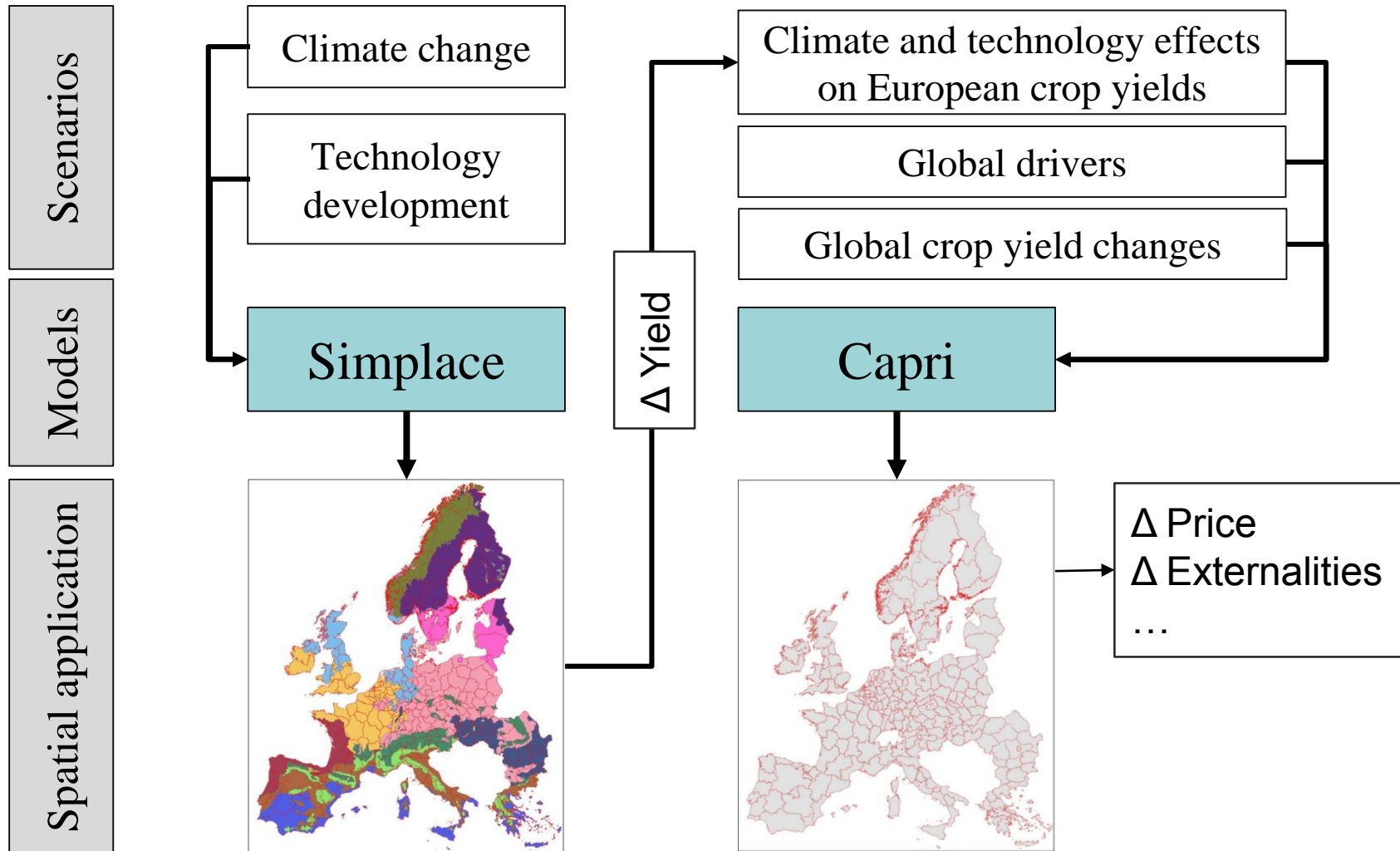
$\hat{y}$ ... estimated average yield  
 $w$ ... area weight of region  
 $\text{var}^*(\hat{y}_s^*)$ ... Variance  
 $s$ ... stratum  
 $n$ ... number of points in stratum  
 $t$ ...



# Model linkages



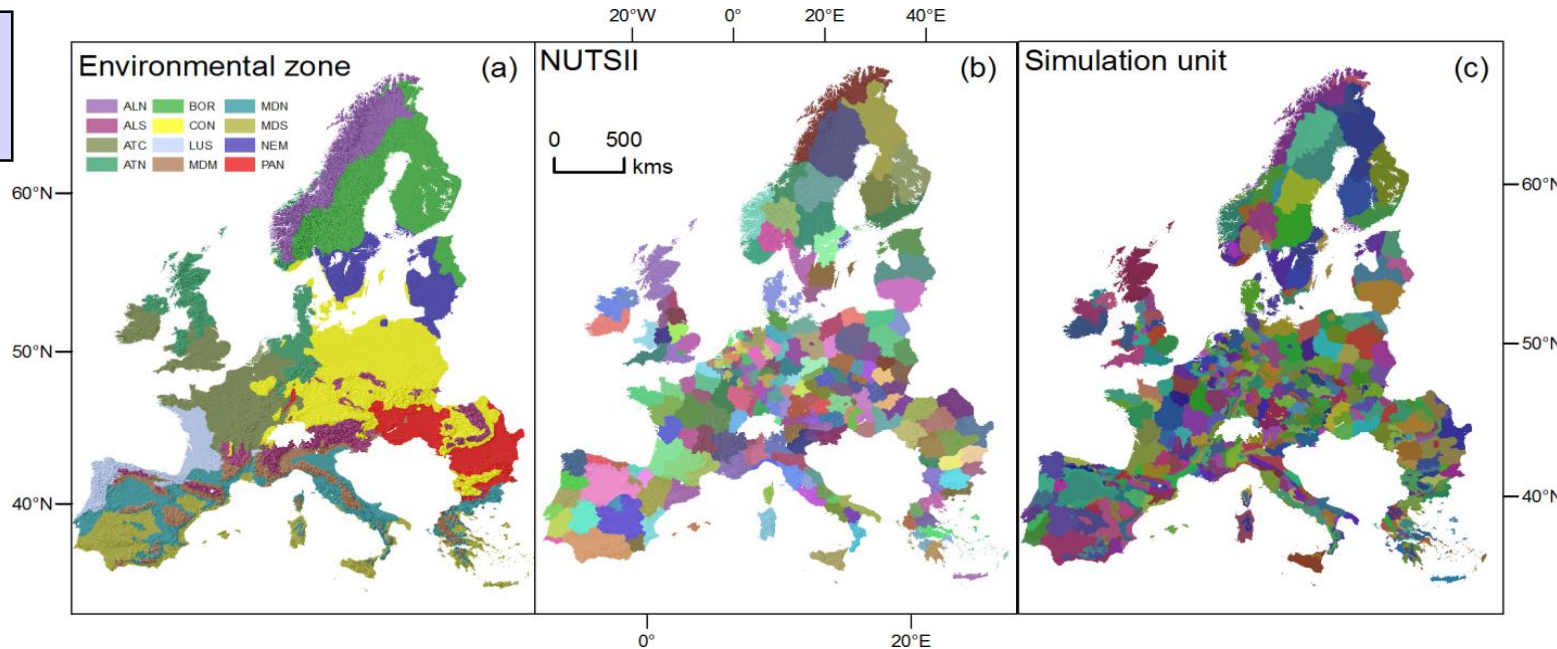
Linking crop and econ (trade) model





# Model linkages

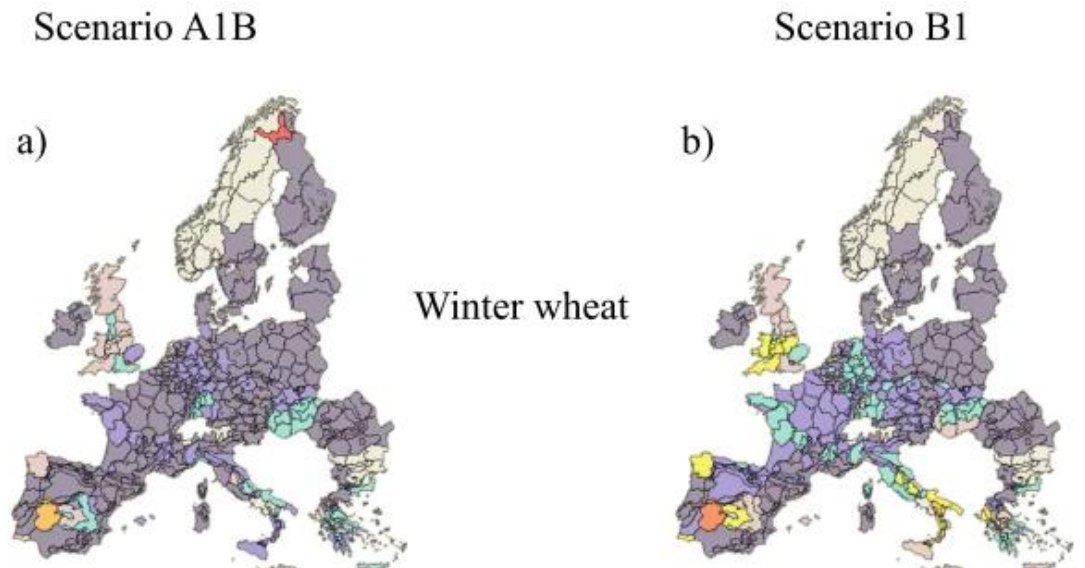
## Matching regionalisation



Zhao et al, 2015

## Estimated yield changes

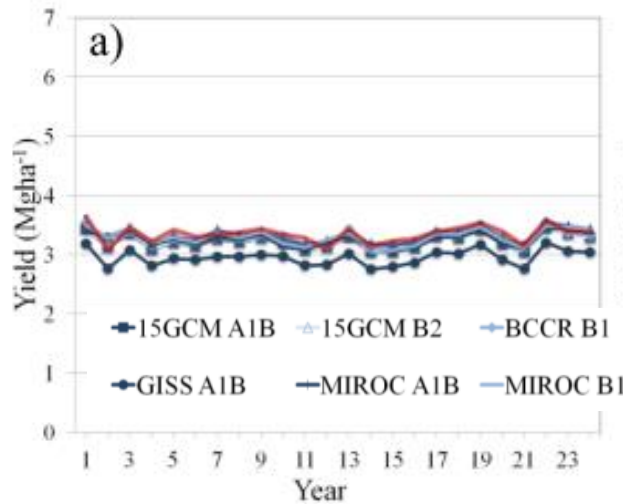
Yield difference from baseline (%)



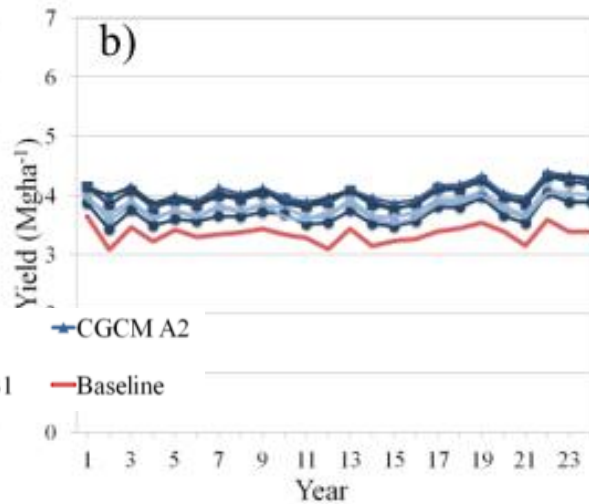
Angulo et al, 2013

# Model linkages

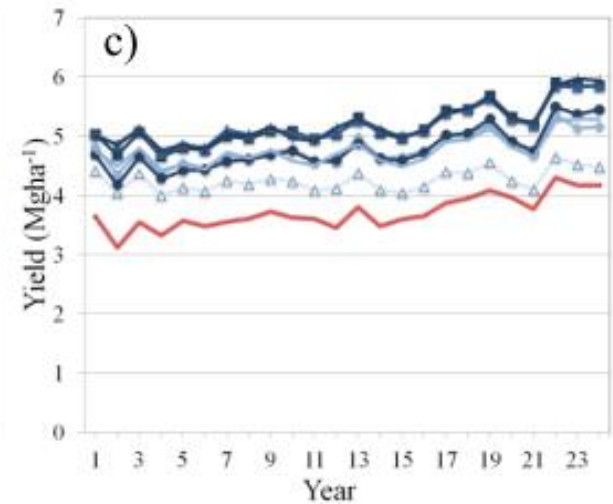
Climate



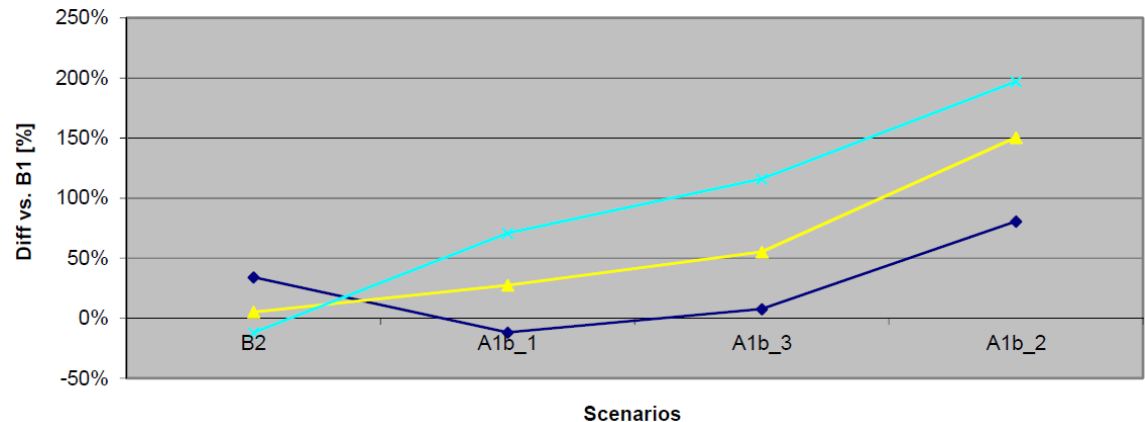
Climate and CO<sub>2</sub>



Climate, CO<sub>2</sub> and technology



Development of Wheat Price in EU27



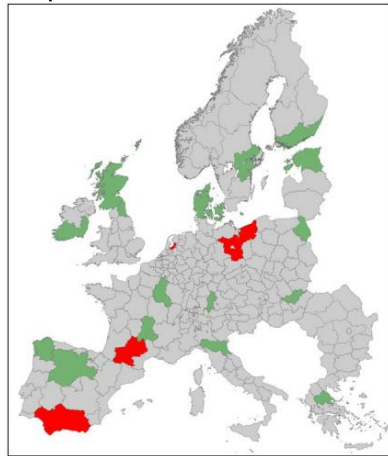
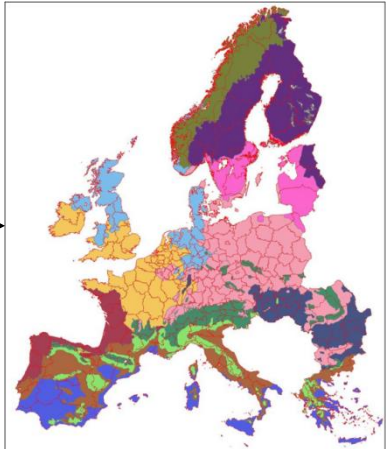
Ewert et al, 2012

Angulo et al, 2013

Estimated price changes

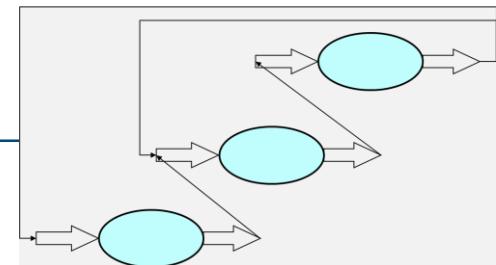
The diagram shows a parallel circuit with three branches. Each branch contains a light bulb. The circuit is connected to a power source on the left. The top branch contains a light bulb, the middle branch contains a light bulb, and the bottom branch contains a light bulb. The circuit is completed by a wire on the right that connects back to the power source.

## Linking crop, farming system, trade and N uptake/loss models



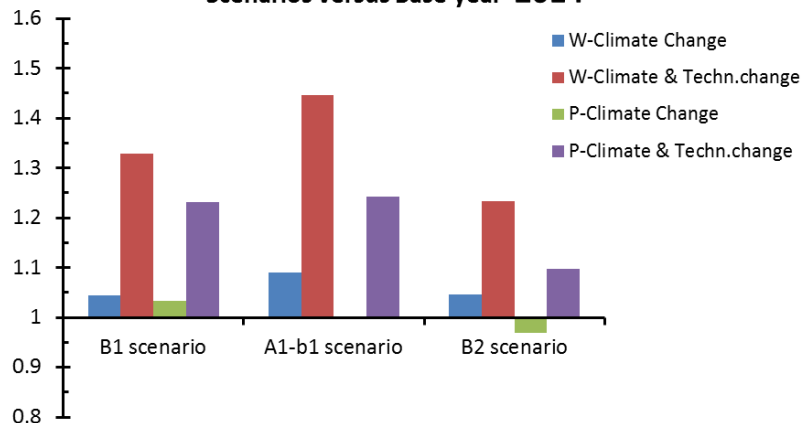
# Model linkages

Linking crop, farming system, trade and N uptake/loss models



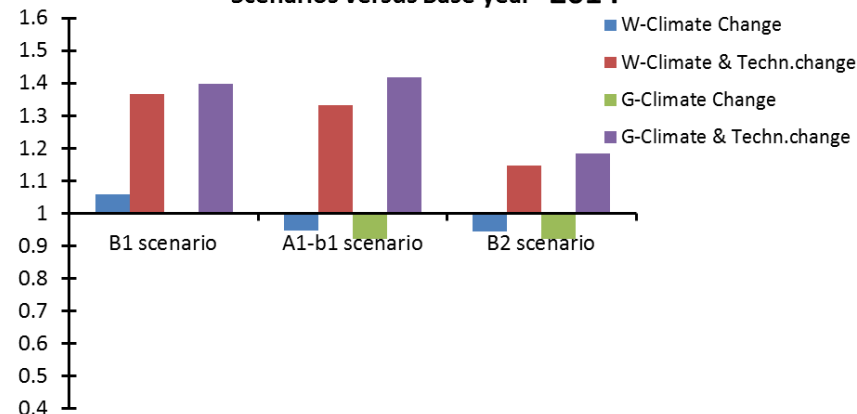
**Flevoland - Ratio Wheat & Potato DM Yields**

Scenarios versus Base year 2014



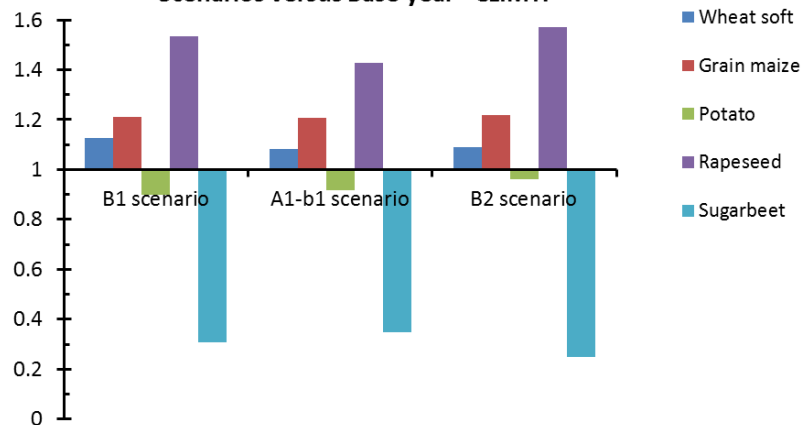
**Midi Pyrénées - Ratio Wheat & Grain maize DM Yields**

Scenarios versus Base year 2014



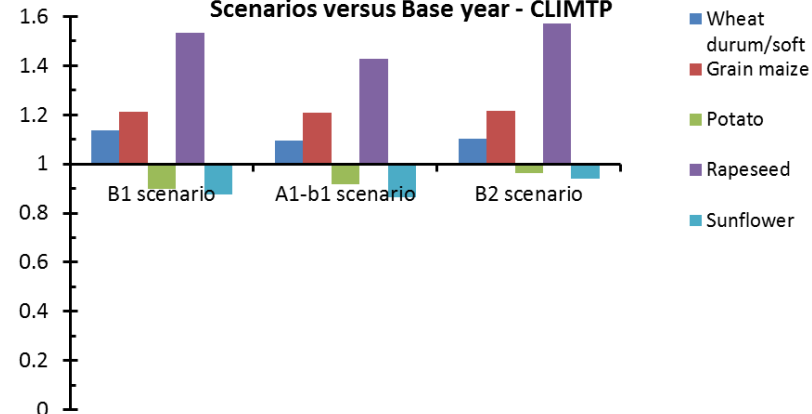
**Flevoland - Ratio Product prices 2014**

Scenarios versus Base year - CLIMTP



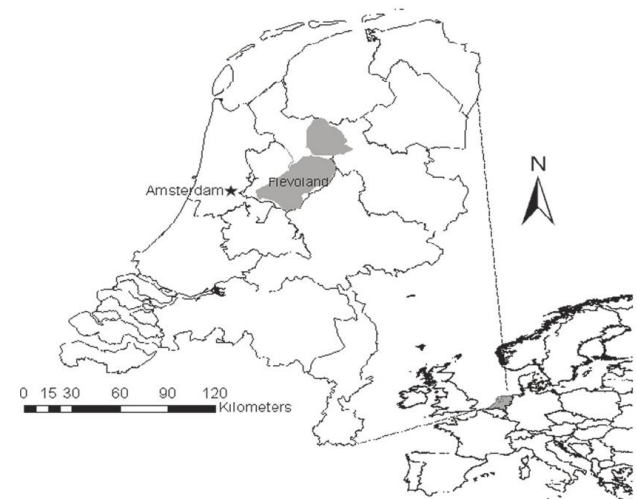
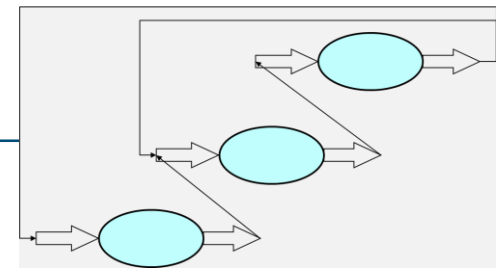
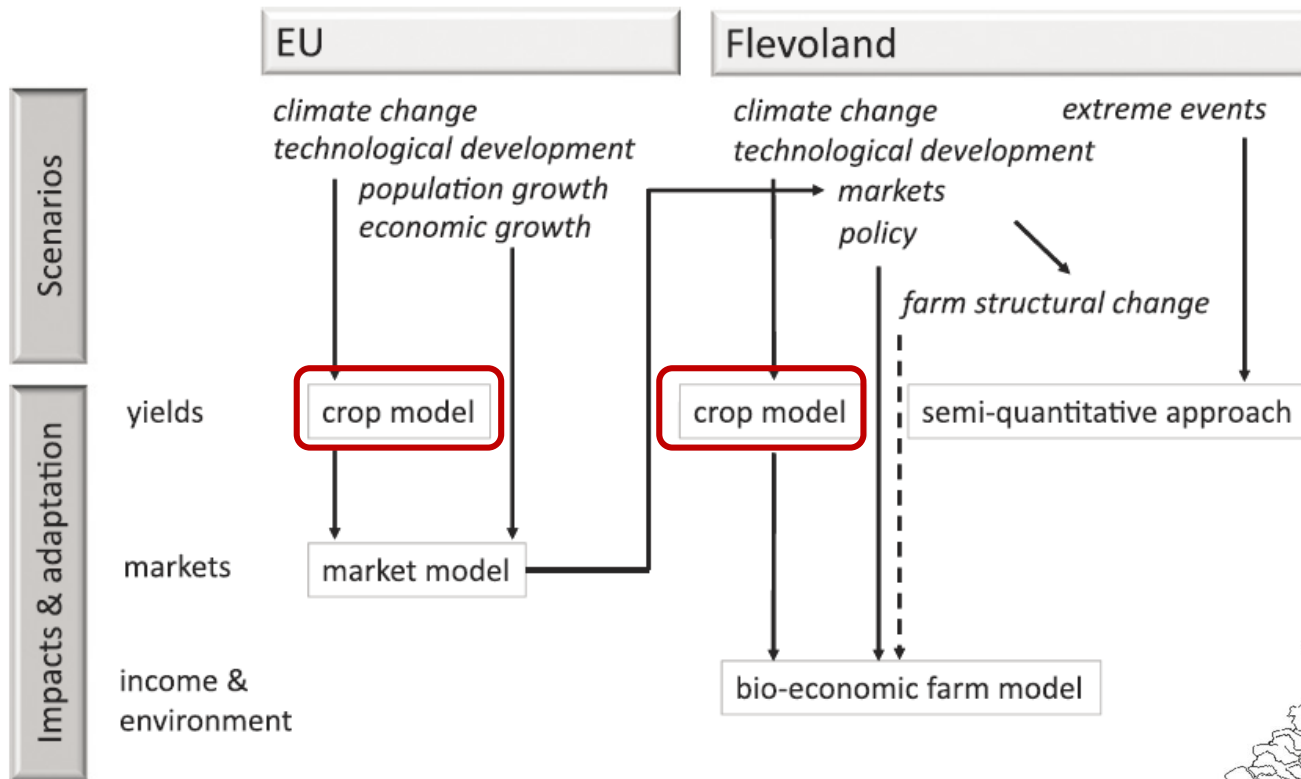
**Midi Pyrénées - Ratio Product prices 2014**

Scenarios versus Base year - CLIMTP

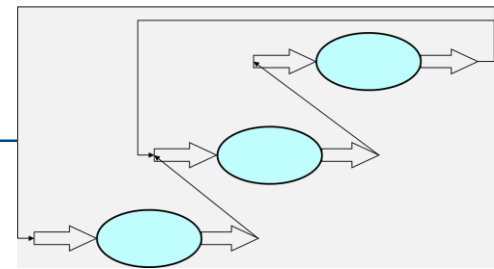


# Model linkages

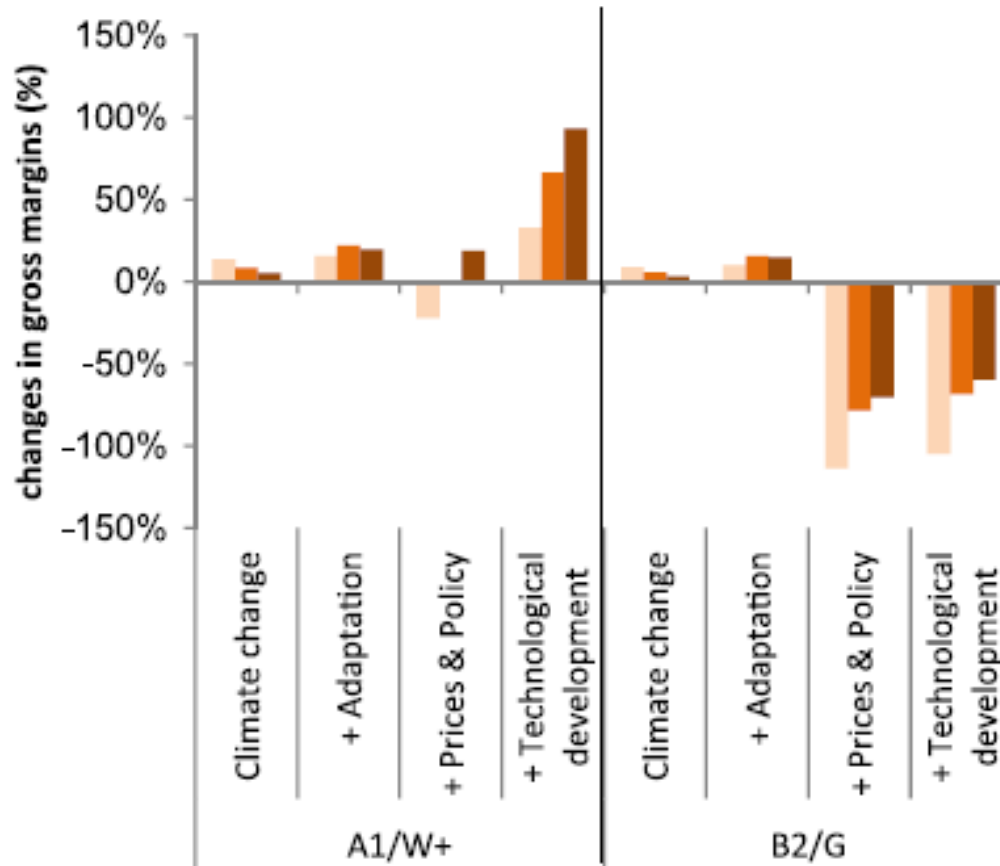
Linking **crop** and trade and  
**Crop** and farming system model



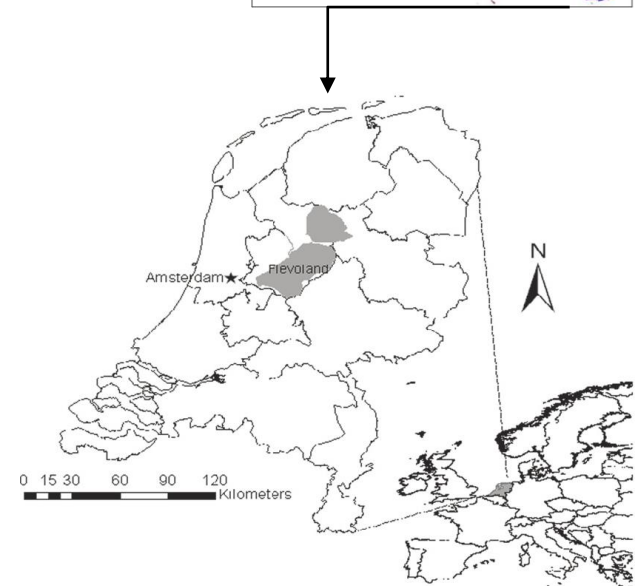
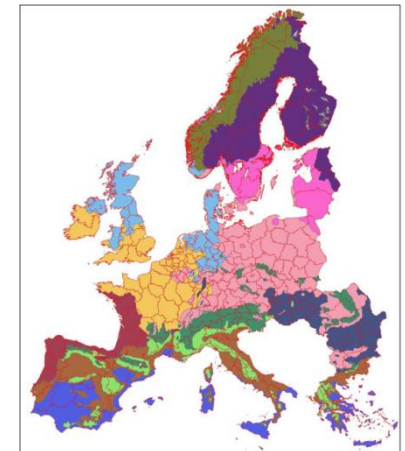
# Model linkages



## Effects on farm types



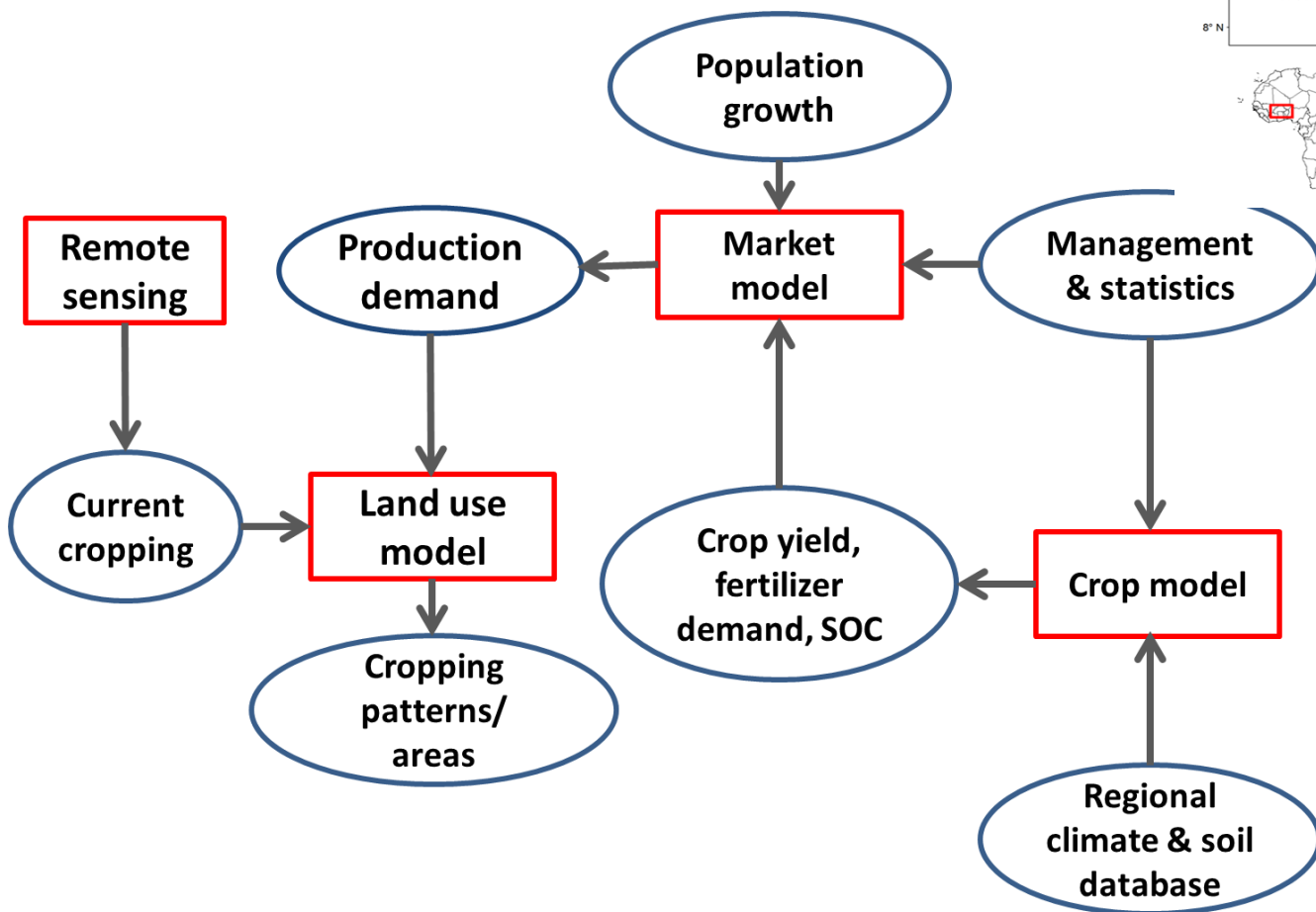
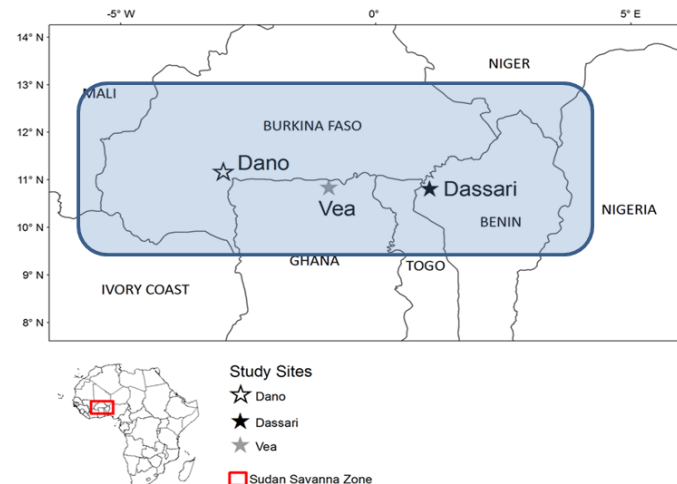
Medium  
Large  
Very large





# Model linkages

Linking crop, market, land use model with remote sensing data

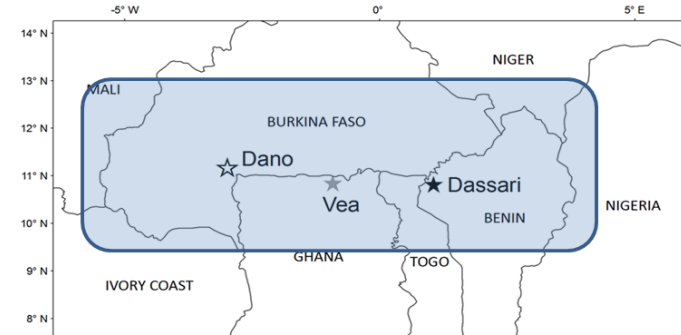




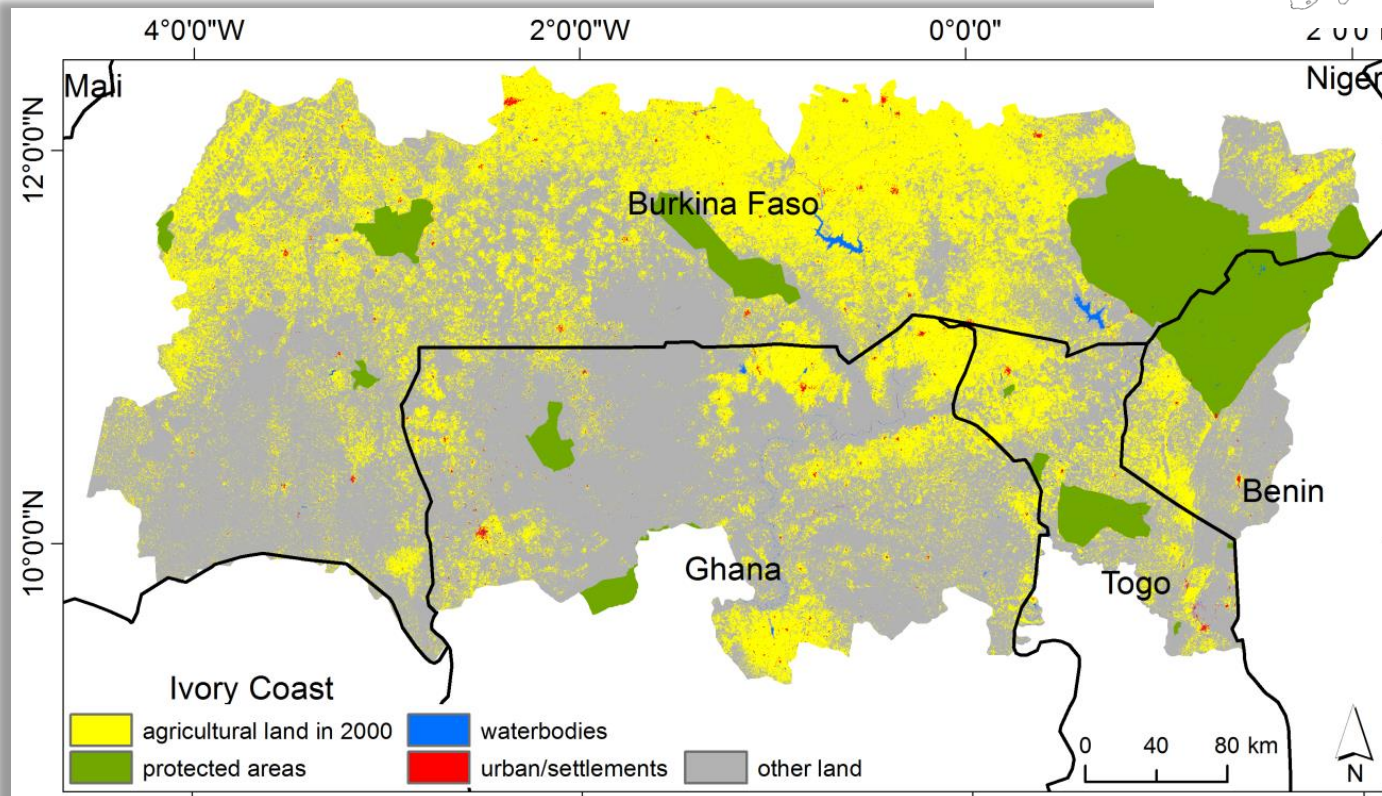
# Model linkages

Linking crop, market, land use model with remote sensing data

# WASCAL



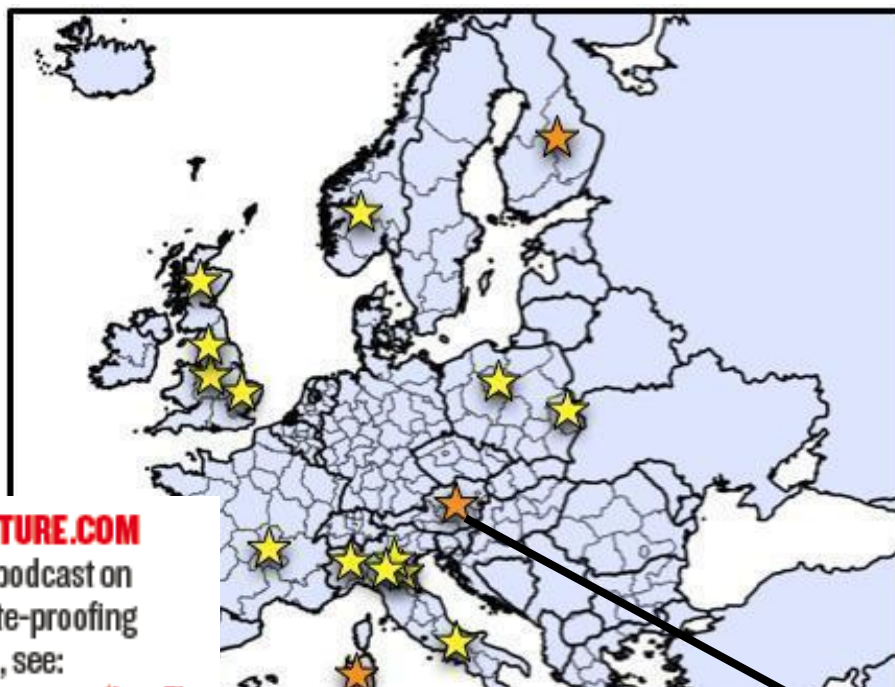
Study Sites  
★ Dano  
★ Dassari  
★ Veia  
□ Sudan Savanna Zone



# Model linkages



Towards a global/European – regional assessment



Finland: Northern Savo

Austria: Mostviertel

Italy: Oristano, Sardinia

Focus: 2020, 2030, 2050

Integration of models;  
participation of stakeholders;

**NATURE.COM**  
For a podcast on  
climate-proofing  
farms, see:  
[go.nature.com/lqrg5h](https://go.nature.com/lqrg5h)

*“Farmers seek to be profitable in the very near-term. From their perspective, 2040 is light years away.”*



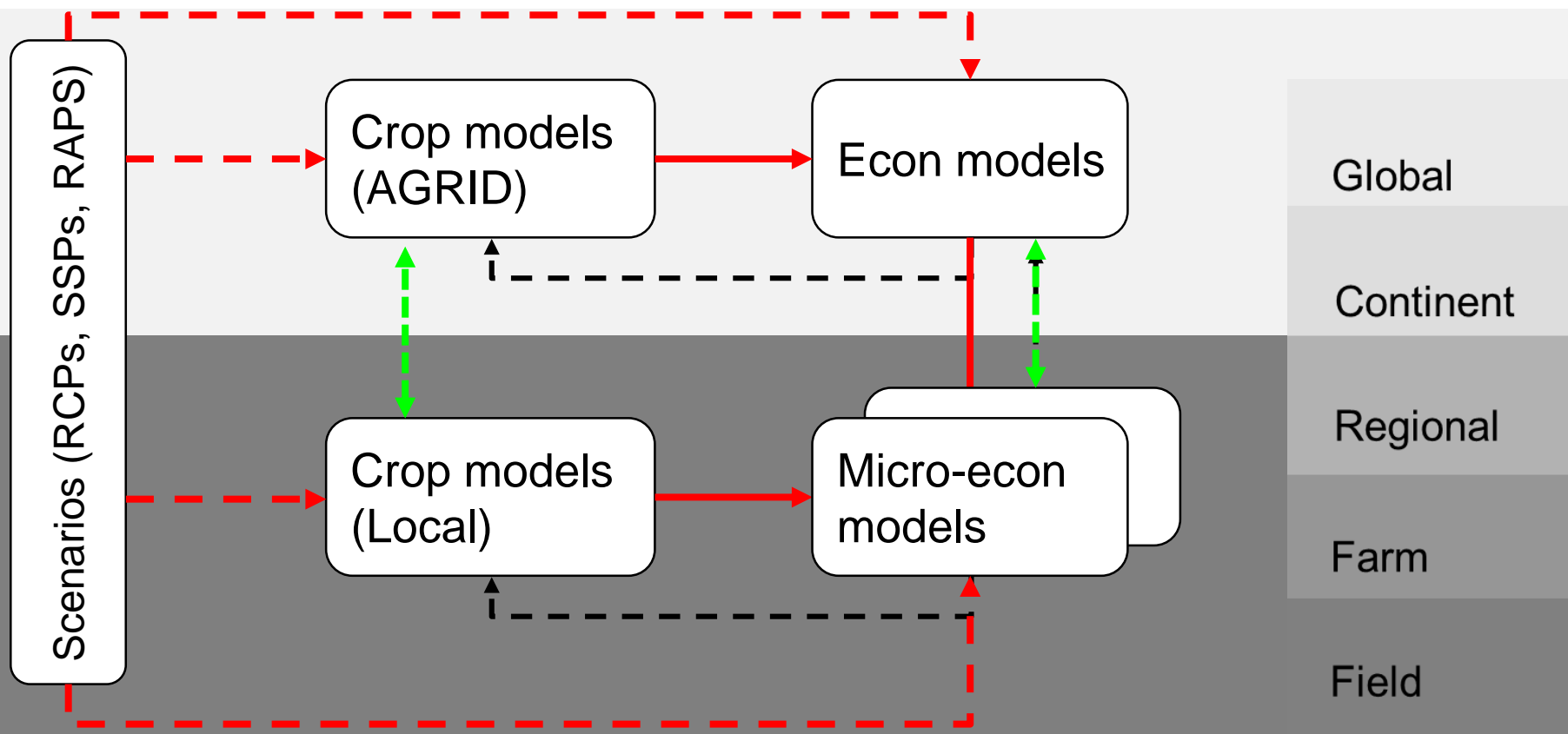
FEATURE NEWS

## Quest for climate-proof farms

Climate change is a major threat to food production, so researchers are working with farmers to make agriculture more resilient.

# Model linkages

## Proposed framework



- Impact assesment
- -> Possible feedbacks
- -> Learning (model improvement)

# Conclusions/challenges on global to regional studies

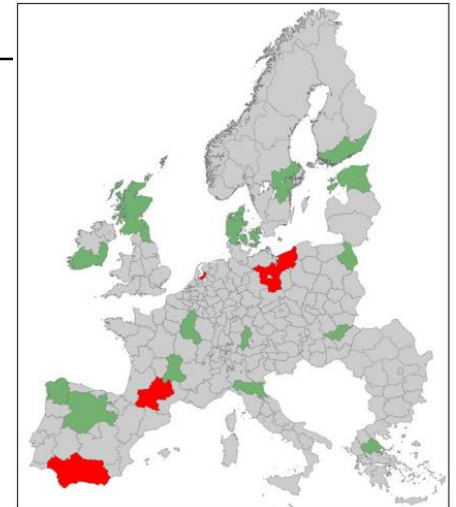
Key challenges



Integration of regional assessments

## Clarification about differences among regional studies:

- Issues at stake
- Scales (farm, landscape, region)
- Types of models used
- Output variables
- Ways of exchanging data
- Methods of parameterization, initialization (model set-up)
- Scenarios





# References

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Angulo, C., Rötter, R., Lock, R., Enders, A., Fronzek, S., Ewert, F., 2013. Implication of crop model calibration strategies for assessing regional impacts of climate change in Europe. *Agricultural and Forest Meteorology* 170, 32-46.

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