

# **What is a virtual plant good for?**

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# Crop Simulation Models

**Modeling the most important interdependences and processes of the atmosphere-soil-plant system**

**Description of processes:**  
*functions, differential equations and complex algorithms...*  
*implemented in a software*

# Crop Simulation Models

**Required data:**

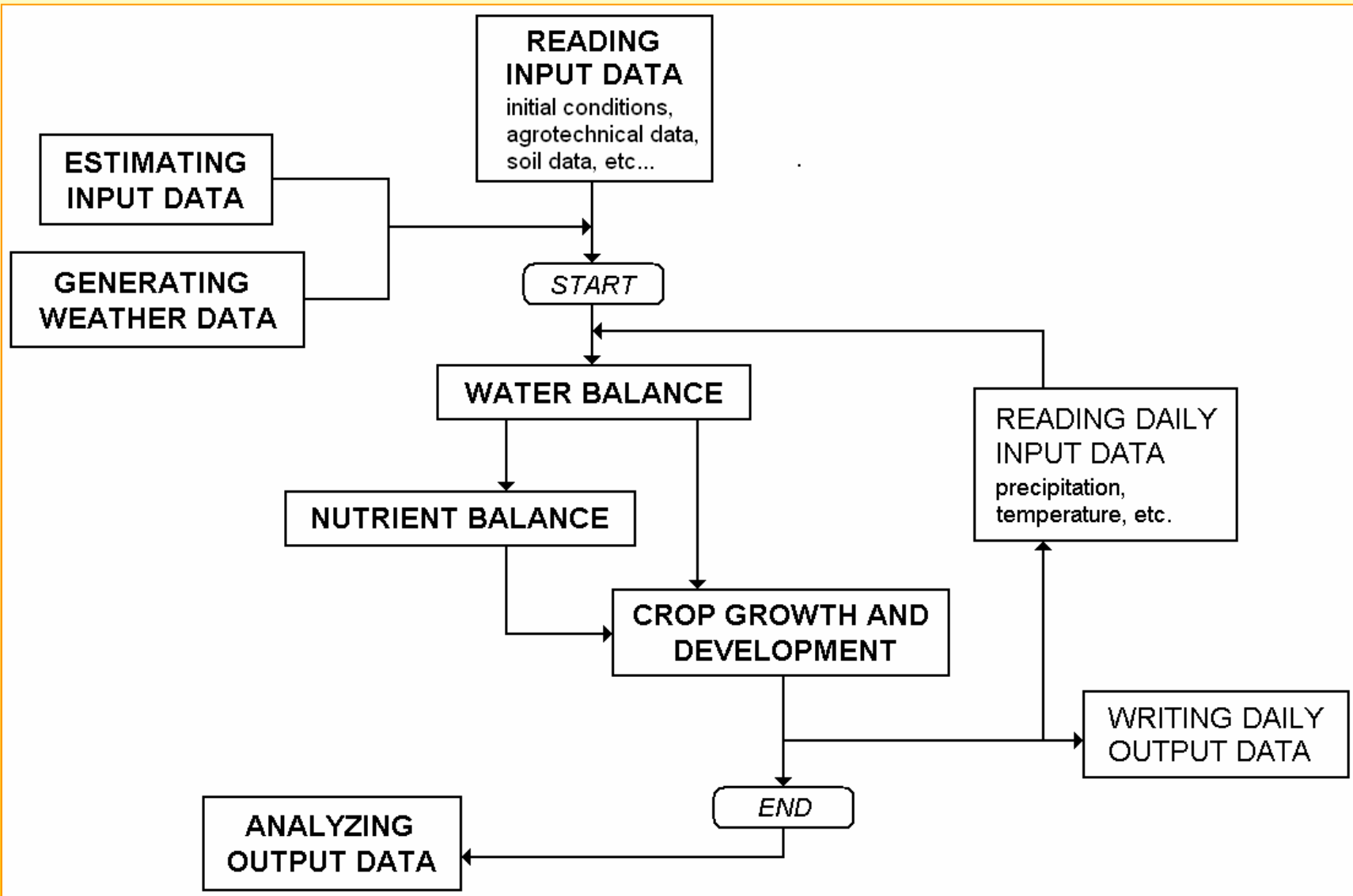
**Parameters:** physical, chemical and biological  
characterization of the system:  
*DUL, pH, T<sub>base</sub> ...*

**Initial conditions:** *water content ...*

**Boundary conditions:** *met. data ...*

**Agro-technical conditions:** *planting ...*

# Crop Simulation Models



# Crop Simulation Models

**Beginnings during the Cold War:**  
*Give a 'better' estimate for the volume of winter wheat production of the SU*

**Problem #1: *slow hardware***

<b>Year</b>	<b>Processor</b>	<b>Run time</b>
<b>1993</b>	<b>286</b>	<b>&gt;8 hour</b>
<b>2005</b>	<b>P4</b>	<b>27 sec</b>
<b>2007</b>	<b>AMD Opteron</b>	<b>4 sec</b>

# Crop Simulation Models

**Problem #2: *fix software* »  
*cumbersome development***

$$DM = 2.1 \cdot \frac{GR \cdot (1 - e^{c \cdot LAI})}{PD} \cdot \min(S_1, S_2, \dots)$$

**Problem #3: *lack of data***

- » **Weather Generator**
- » **Soil Par. Estimator**

# **What are the Crop Simulation Models good for?**

**Education: virtual crop production  
competition**

**Research: extrapolating the results of  
experiments in space & time**

**Practice: irrigation control,  
search for adaptation  
strategies for sustainable  
agriculture**

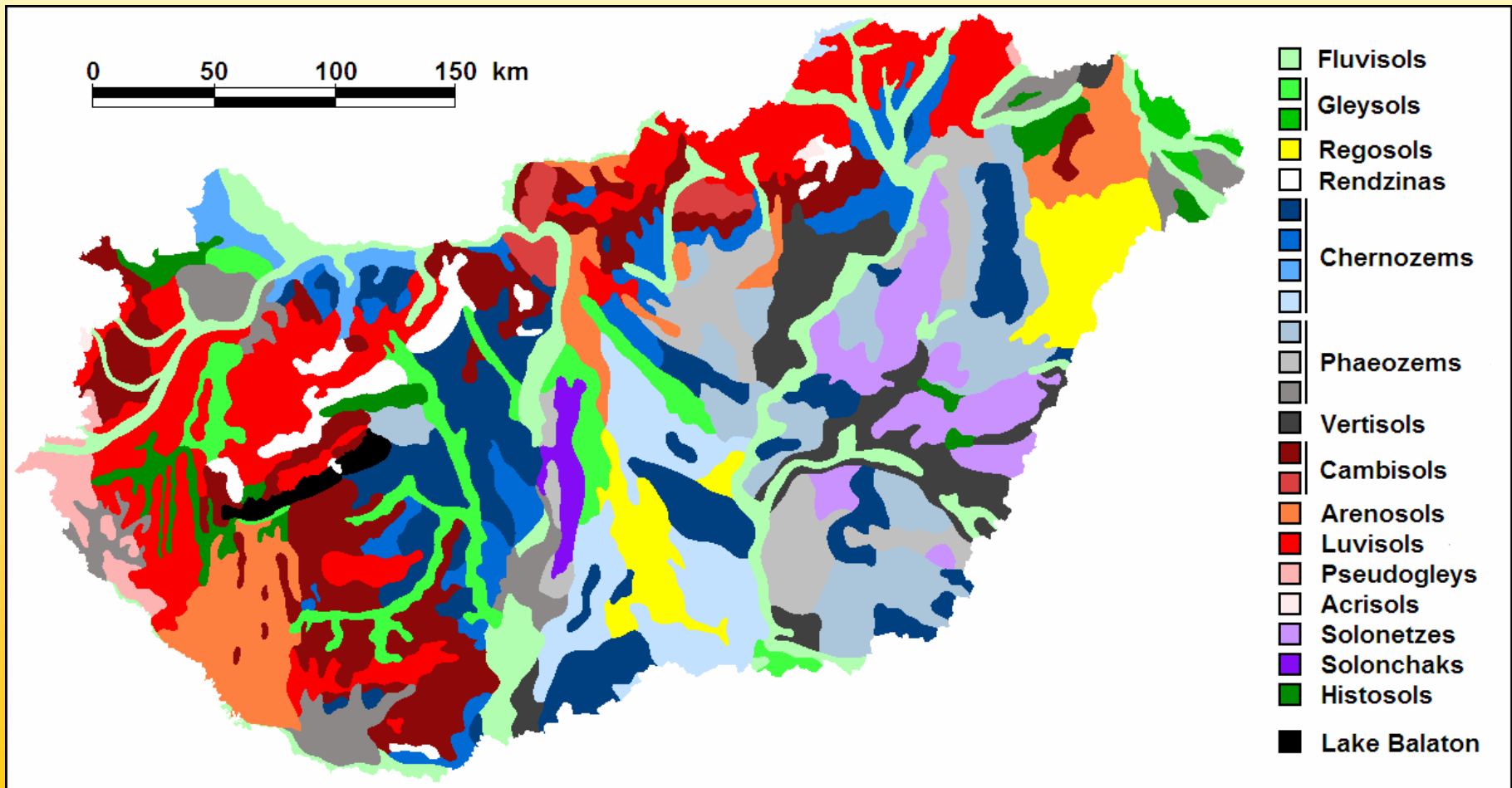
**Extrapolating experiment results in space & time**

# **Nitrate profiles at Nagyhörcsök, Hungary**

# Extrapolating experiment results in space & time

## Prospective effects of climate change

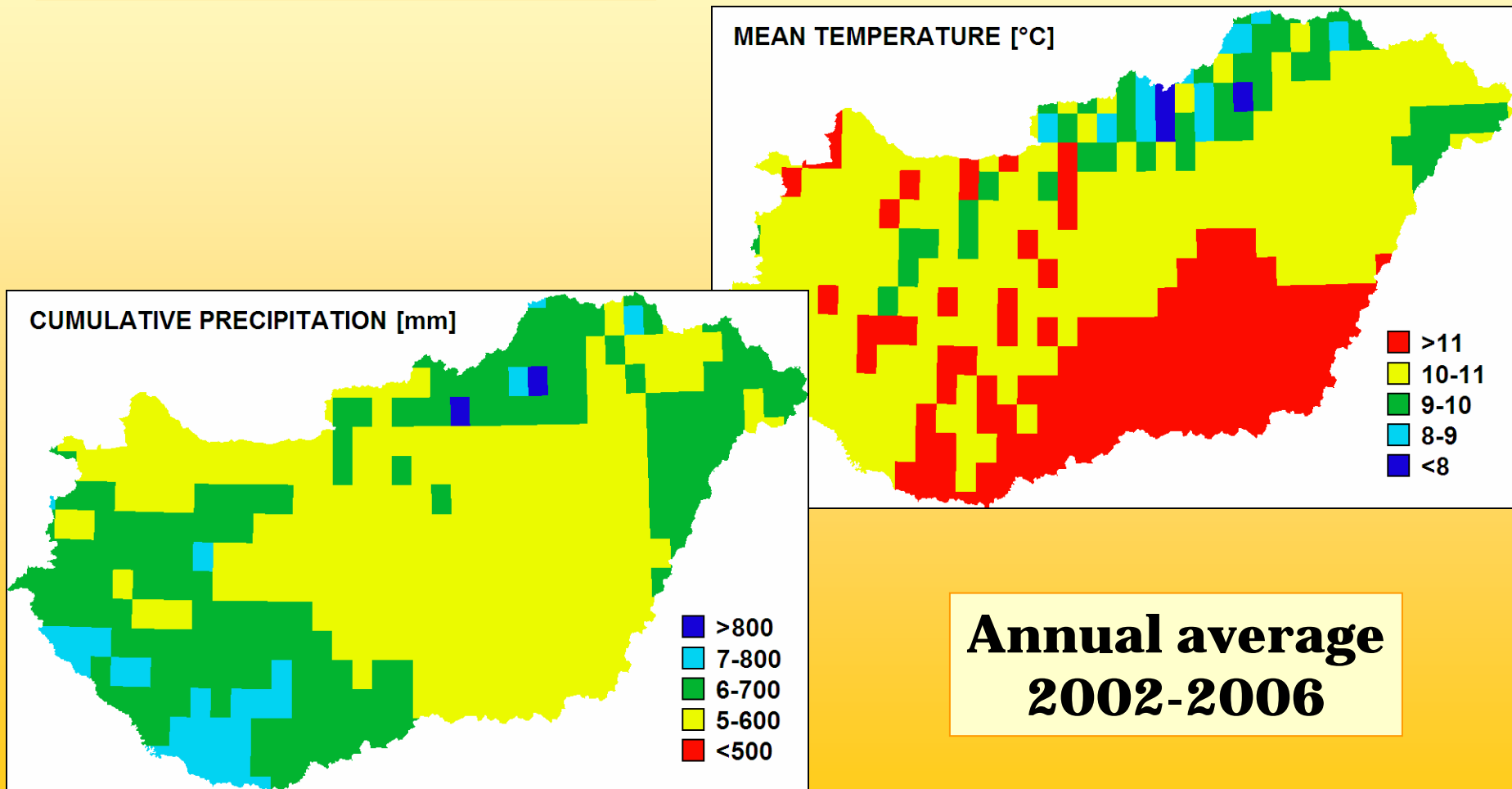
### Soil data...



# Extrapolating experiment results in space & time

## Prospective effects of climate change

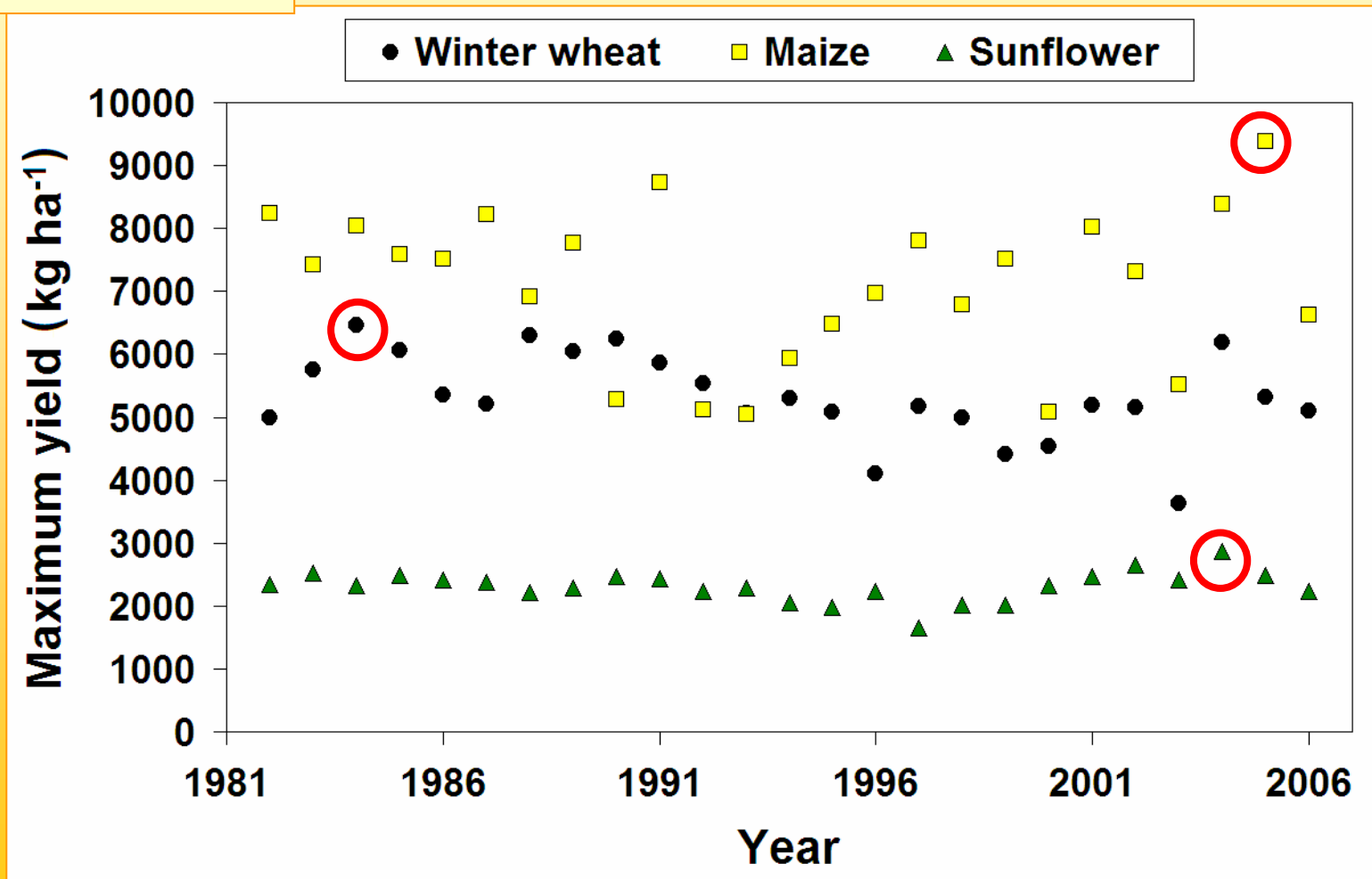
### Meteorological data...



# Extrapolating experiment results in space & time

## Prospective effects of climate change

### Plant data...



Extrapolating experiment results in space & time

# Prospective effects of climate change

## Estimated scale of climate change by 2100

Parameter	Mathematical operation	Winter	Spring	Summer	Autumn
Temperature (°C)	Add	3.2	2.3	2.8	2.7
Precipitation (mm)	Multiply	1.11	1.04	0.91	0.99
CO <sub>2</sub> (ppm)	Fix value			557	

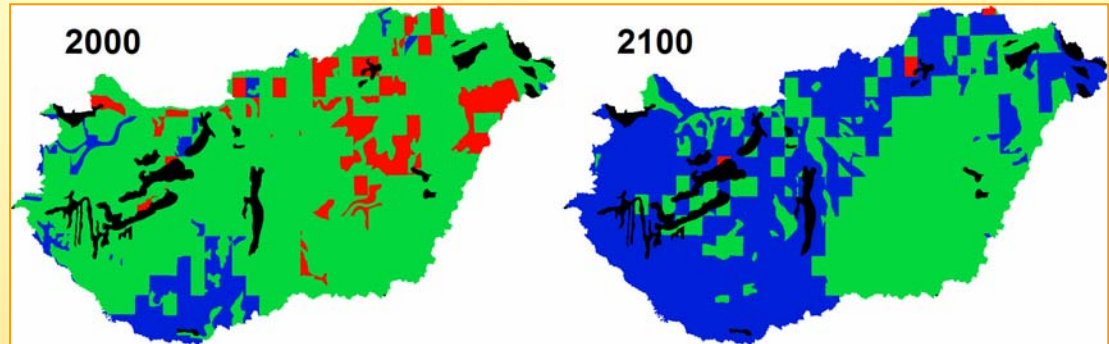
# Extrapolating experiment results in space & time

## Prospective effects of climate change

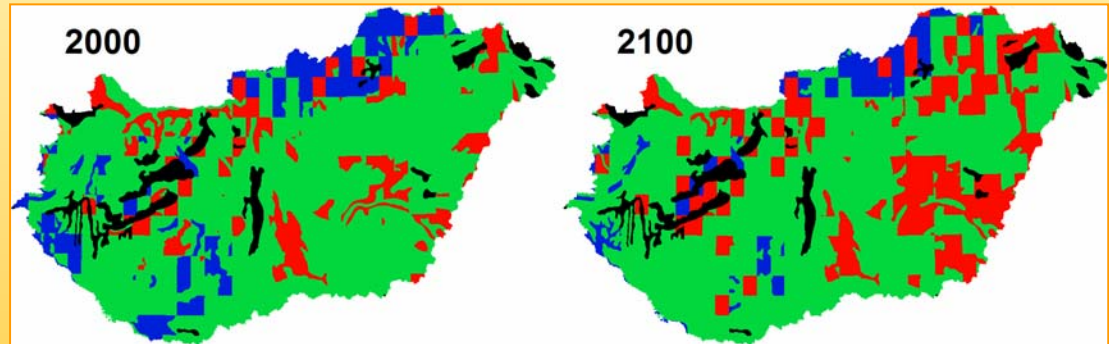
**Yield**

**below average**  
**average**  
**above average**

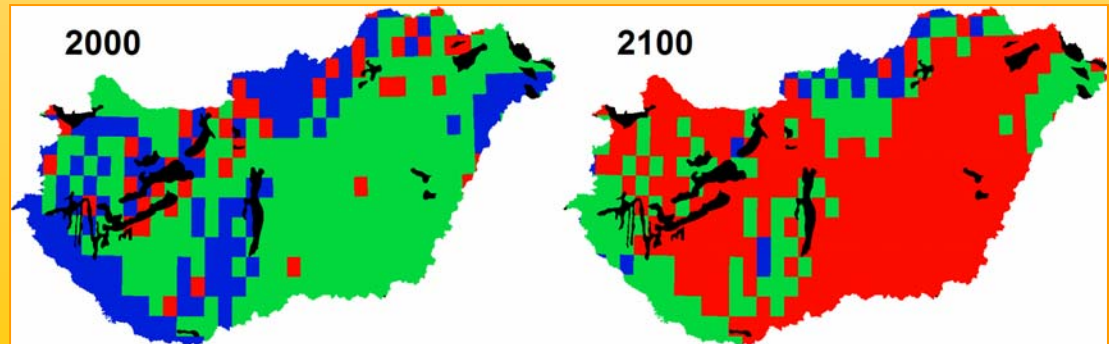
**win. wheat**



**maize**



**sunflower**

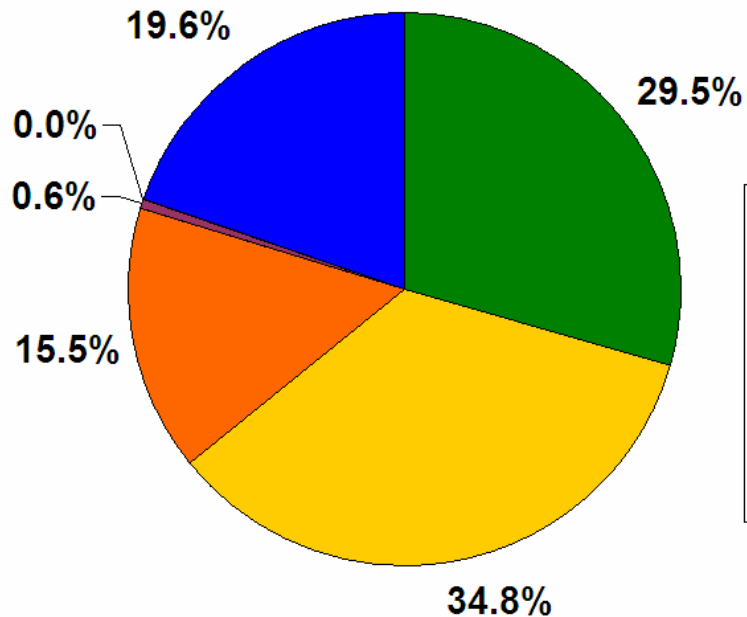


# Search adaptation strategies

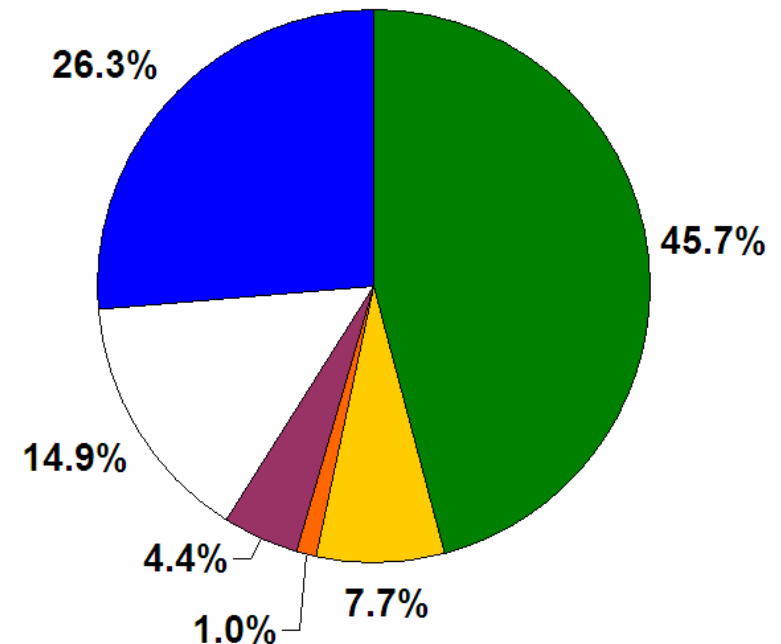
## » Spatial analogies - 2060

### Distributions of sowing areas

#### CARPATHIAN BASIN



#### NORTHERN GREECE



# Search adaptation strategies

**If farmers would use the method of spatial analogies for adaptation to the possible changes the cost of subduing the harmful effects of the climate change might be decreased with several billion dollars even in the case of a couple of degrees of temperature rise.**

*Adams R.M. et al., 1998 – Climate Research*

# **Search adaptation strategies**

- 1. Set up agr-met stations with alternative crops**
- 2. Create COMPLETE & HOMOGENOUS database**
- 3. Calibrate crop simulation model**
- 4. Combine model with climate change and agro-technical scenarios**
- 5. Extensive analysis of output data**