Uncertainties in Scaling Up Crop Models for Large Area Climate Change Impact Assessments

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Outline

- Introduction (crop modelling and uncertainty)
- Methods of up-scaling
- Selected results
  - AgMIP regional scaling pilot
  - Other studies (Finland, MACSUR)
- Concluding remarks
Introduction

Crop system model

Model
(crop growth and development)

Sources of uncertainty

Input data
- Climate, soil, management
- Genetic characteristics

Model
- Structure
- Parameters

Output data
- Post processing
- Observations

Scaling method
- Input data
- Model
- Output data
**Introduction**

Scaling and uncertainty

Crop and higher level systems

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**Region and higher level**

**Scaling method**
- Input data
- Model
- Output data

**Field level**

**Productivity (region)**

**Productivity (crop)**
### Scaling methods

**Scaling of input data (selection)**

- **High resolution simulation for all points in the region** = ‘True’ value

- **Sampling of region** = ‘Averaged’ value

- **Aggregation of data to strata or grid cells** = ‘Aggregated’ value

Modified from Ewert et al, 2011
Results (sampling)

The region in Germany (North Rhine-Westphalia)
Results (sampling)

The scaling method

High resolution simulation for all points in the region (ca. 34000 grids with 1 km x 1 km) = ‘True’ value

Stratified sampling = ‘average’ value
- 50 points
- 100
- 500
- 1000
## Results (sampling)

### The models

<table>
<thead>
<tr>
<th>Model</th>
<th>Potential yield</th>
<th>Water-limited yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCWLA</td>
<td>Early Nov</td>
<td>Yes</td>
</tr>
<tr>
<td>NWheat</td>
<td>Yes</td>
<td>Early Nov</td>
</tr>
<tr>
<td>pDSSAT</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>SALUS</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>SIMPLACE &lt;LINTUL&gt;</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>SPASS</td>
<td>Not possible</td>
<td>Yes</td>
</tr>
<tr>
<td>APSIM</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>DSSAT</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>STICS</td>
<td>later</td>
<td>later</td>
</tr>
</tbody>
</table>
Results (sampling)

The results (spatial pattern), one model
Results (sampling)

The results, observed (1999-2011)

Temporal variability

Mean observed Yield (1999-2011)
**Results (sampling)**

The results (temporal pattern), different sampling points, one model

**Potential yield**

**Water-limited yield**
Results (sampling)

The results (temporal pattern), different sampling points

Potential yield

Water-limited yield
### Results (sampling)

The results (effect of sampling), one model

**Expectation for MSE E(MSE)**

\[
E(MSE_{n_1,n_2,n_3,n_4}) = \text{bias}(\hat{y})^2 + \sum_{i=1}^{4} w_i^2 \text{var}(\hat{y}^{* s_i}) / n_s
\]

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

The results (effect of sampling), different models

![Graph showing different models with all grid cells and a sample size of 100](image)
Results (sampling)

The results (effect of sampling), different models, different weather variables
Results (aggregation, selected example MACSUR)

Comparison of:
• Data aggregations
• Models
• Output data types

Example Germany (NRW)

<table>
<thead>
<tr>
<th>Resolution</th>
<th>Average precipitation (1981-2010)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 x 1 km</td>
<td>&gt; 1300 mm &lt; 600 mm</td>
</tr>
<tr>
<td>10 x 10 km</td>
<td></td>
</tr>
<tr>
<td>25 x 25 km</td>
<td></td>
</tr>
<tr>
<td>50 x 50 km</td>
<td></td>
</tr>
<tr>
<td>100 x 100 km</td>
<td></td>
</tr>
</tbody>
</table>
Comparison of:
- Data aggregations
- Models

1 Station
10 x 10 km
20 x 20 km
50 x 50 km
100 x 100 km

Angulo et al, 2012
Concluding remarks

- Relatively small effect of sampling size (and aggregation)
- Large differences among models
- Interaction between required sample size and model
- Next
  - Spatial variability in soils and management
  - More on effect of aggregation (grid cells)
  - Other regions, crops, output variables (MACSUR)
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Thank You
Results (sampling)

The results (spatial pattern), different models

Potential

Model 1

Model 2

Model 3

Water-limited

Model 1

Potential

Model 4

Model 5

Model 6

Water-limited

Model 4

Model 5

Model 6
Results (sampling)

The results (temporal pattern), different sampling points, different models

Potential yield

Water-limited yield
Comparison of:
• Input vs. Output aggregations
• With observations

Results (aggregation)