Use of LTE data for cross-scale cropping system modelling and assessment

Frank A Ewert

Leibniz Center for Agricultural Landscape Research (ZALF) e.V., Germany
INRES-Crops Science, University of Bonn, Germany

Rothamsted, 21st – 23rd May 2018
Crop and cropping system models

Crop models

Physiological processes

Breeding

Atmosphere

Crop

Soil

Management

Weather and CO₂

Radiation interception

Assimilation

Respiration

Allocation

Organ growth

Leaves, stems, ...

Roots

Plant N

ET

Soil H₂O, N and C
Crop and cropping system models

- **Variables**
  - Dynamic
  - Deterministic
  - Process-based
  - Numerical simulation

- **Model type**
- **Factors**
  - Climate
    - Temperature
    - Precipitation
    - Radiation
    - CO₂
    - ...
  - Soil
    - H₂O
    - C, N, P, K
  - Management
    - Irrigation
    - Fertilization
    - Varieties
    - Sowing date
    - Pests, diseases
    - Rotation
    - Tillage
    - ...

Graph showing growth over time:
- Stems
- Roots
- Grains
- Total Biomass
- LAI

Graph axes:
- g m⁻²
- Day of the year
- LAI
- g m⁻²
Crop and cropping system models

Crop model

Atmosphere

Crop

Soil

Management

Breeding

Cropping system model

Crop 1

Crop 2

Crop n

time
Main areas of model application

Research
- Impact assessment
- Integrated modelling
- Observational data analysis
- Model comparison and improvement
- Functional Structural Plant Modelling
- Genetic modelling
- Virtual phenotyping

Teaching
- Markets
- Farming systems
- Yield gap analysis

Decision support
- Land use
- Farming systems

Communication
- Observation data analysis
- Integrated modelling
- Research

Globe
- Continent
- Country
- Region
- Farm
- Field
- Organism
- Organ
- ...
Aspect of scale

Scaling crop system models

Sources of uncertainty

<table>
<thead>
<tr>
<th>Input data</th>
<th>Model</th>
<th>Output data</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Climate, soil, management</td>
<td>• Structure, Parameters</td>
<td>• Post processing, Observations</td>
</tr>
</tbody>
</table>

Asseng et al, 2015

Ewert et al, 2013

Example, wheat yield

Global

Germany

NRW

Bonn

6% decline in global wheat production for each degree in global warming
Crop modelling and LTE

Model inputs (potentially) available from LTE

- Climate, CO₂
- Soil characteristics
- Crop characteristics
- Management (NPK, manure, ...)

- Time series (but changes in M, G)
- (Spacial variability ➔ multiple sites)
- Rotations

Data

Broadbalk Winter Wheat experiment, Rothamsted


Graph

Johnston and Poulton (2018)
Examples of using LTE data for modelling

Modelling soil properties
Example: soil C

Example: RothC with data from LTE Rothamsted, spring barley

Sim und Obs organic carbon

Multi-site experiments
Example: soil C

Johnston et al., 2009 in Johnston and Poulton (2018)
Examples of using LTE data for modelling

Few studies to model soil and crop processes

Kersebaum, (2007)
Examples of using LTE data for modelling

Few studies to model soil and crop processes \(\rightarrow\) multi-model simulations

Kollas et al., (2015)
Examples of using LTE data for modelling

? Modelling long time series of crop and soil variables

?? Parameterisation for changing varieties?

Yield change and variability of winter wheat in the long term fertilization experiment, Dikopshof, Bonn, 1953-2013

Examples of using LTE data for modelling

Modelling long time series of crop (and soil) variables;
Example phenology

Direct comparison of winter wheat varieties grown at Dikopshof, Bonn, 1952-2013

New cultivar (Tommi)
Old cultivar (Heines VII)

Challenges and opportunities (scaling)

Up-scaling → crop/soil responses

- Sampling
- Aggregation

- Soil
- Climate
- Management
- Crop rotations

Ewert et al, 2014

Up-scaling: crop/soil responses

a) High resolution data

b) Changing size of grid cells

10 x 10 km²
25 x 25 km²
50 x 50 km²
100 x 100 km²

https://eoimages.gsfc.nasa.gov/images

Ewert et al, 2014
Challenges and opportunities

Up-scaling
- Sampling

Zhao et al, 2016
Challenges and opportunities (scaling)

Aggregation of rotation

a) $M_i$... Monocrop, initialised per a
b) $M_c$... Monocrop, continuous
b) $R_s$... Crop rotation, instance
b) $R_s$... Crop rotation, aggregate

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>...</th>
</tr>
</thead>
<tbody>
<tr>
<td>$M_i$</td>
<td>Autumn Wheat</td>
<td>Autumn Wheat</td>
<td>Autumn Wheat</td>
<td>Autumn Wheat</td>
<td>Autumn Wheat</td>
</tr>
<tr>
<td></td>
<td>Green-feed</td>
<td>Green-feed</td>
<td>Green-feed</td>
<td>Green-feed</td>
<td>Green-feed</td>
</tr>
<tr>
<td>$M_c$</td>
<td>Forage kale</td>
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<td>Forage kale</td>
</tr>
<tr>
<td>$R_s$</td>
<td>Maize</td>
<td>Maize</td>
<td>Maize</td>
<td>Maize</td>
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Month

1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12

Teixeira et al., 2015
Challenges and opportunities (scaling)

Aggregation of rotation
Example: New Zealand

Effect of aggregation methods depends on:
• Crop
• Output variable

$M_i$... Monocrop, initialised
$M_c$... Monocrop, continuous
$R_s$... Crop rotation, instance
$R_c$... Crop rotation, aggregate

Teixeira et al., 2015
Challenges and opportunities

Aggregation / Sampling of rotation

- Soil
- Climate
- Management
- Crop rotations

Soil regions of Germany

The Use of Long Term Field Experiments in Soil Research – The example of Bonares, M Grosse ➔ Tuesday, 11.40-12.30
Fair principles, data management and sharing, repositories and LTE data

Tuesday 15.45-17.00 (C Hoffmann, The Bonares Repository)

Recent data situation

- Often analogue
- Metadata sporadic
- Low accessibility
- Difficult to cite & reuse
- Archiving unsafe

BonaRe Data Repository is „FAIR plus“
follows the FAIR principles AND data are freely available

203 LTFEs
Running times >20 a

Standards
Challenges and opportunities (outlook)

Sensing (FLEX/Sentinel 3), ZALF-Drone

Adjacent experiments

Duration of the LTFE in Germany

Crop

Soil

Farm and landscape Monitoring
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