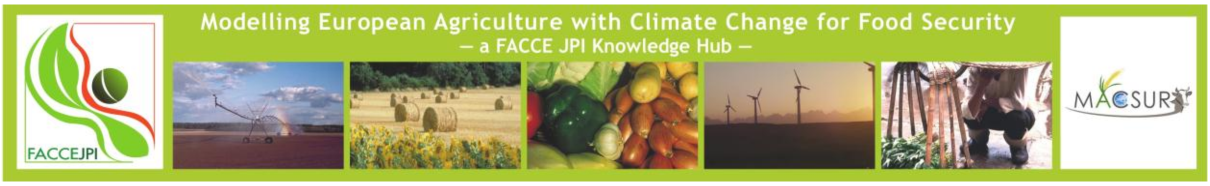

FACCE-MACSUR

Task C1.5: Results of uncalibrated model runs available

Task leader: K.C. Kersebaum* (P147)
Partner involved:
Kollas/Nendel/Wegehenkel/Mirschel (P147)
Ruget/Armas-Herrera,/Launay/Beaudoin/Constantin/Garcia de Cortazar-Atauri/Mary/Ripoche (P196)
Ewert/Hoffmann (P115)
Rötter/Palosuo (P92),
Ventrella/Bindi/Ferrise/Roggero/Moriondo (P62)
Trnka/Hlavinka (P17)
Olesen/Öztürk/Sharif (P189)
Müller/Waha/Wechsung/Conradt (P83)
Lianhai Wu/Whitmore (P65)
Eitzinger
Weigel/Manderscheid

*ckersebaum@zalf.de
Zentrum für Agrarlandschaftsforschung, Eberswalder Str. 84, 15374 Müncheberg, Germany

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Abstract

The study ROTATIONEFFECT aims to compare the output of different models simulating field data sets with multi-year crop rotations including different treatments. Data sets for 5 locations in Europe were distributed to 19 interested modeller groups comprising a total of 201 crop growth seasons. In a first step only minimal information for calibration were provided to the modellers. In total 14 modelling teams sent their "uncalibrated" results as single-year calculations and/or calculations of rotation depending on the capability of the model. 7-10 models were capable to run the rotations as continuous runs. Up to 12 models provided single year simulations of at least one crop. Comparing results of models which provided both single year and continuous runs, show a little lower root mean square error for the continuous rotations runs. Cereal crop yields were generally better simulated than tuber/beet yields. Additionally, the models' response to various treatments (irrigation/rainfed, nitrogen level, CO_2 level, residue management/ tillage, catch crops) were compared to observed differences. First indicators of model performance have been developed and presented at international conferences.

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Introduction

Crop model testing and validation has frequently been based on studies involving single crops ((Palosuo *et al.*, 2011; Rötter *et al.*, 2012; Asseng *et al.*, 2013; Bassu *et al.*, 2014). However, crops may perform differently in the context of different crop rotations. Crop rotation design and management are essential for achieving high yields for food security, sustainable land use considering use and maintenance of and impact on resources, and reducing production risks by diversity of crop production ((Reidsma & Ewert, 2008) under present and future conditions. In response to climate change and/or economic boundary conditions, farmers are already engaged in determining the composition of crop rotations, e.g. by introducing more maize and oilseed rape ((Olesen *et al.*, 2011). However, there is still a lack of studies testing the ability of models to cover the various crop rotation design options. The aim of the study was to investigate the capability of various crop models to handle crop rotations and various management options and to compare results of continuous runs over whole rotations with the performance of single year runs of crops. Data provided should also be used to extend the crop spectrum of individual models in the second step when more details of the observed data will be provided. A great part of the European crop modelling community took the chance in participating in the study ROTATIONEFFECT. Namely, teams from Italy (2), Denmark (2), Germany (5), France (1), Finland (1), UK (1) and Czech Republic (1) were working on simulating the five agricultural datasets provided.

Methods

Following the protocol for model inter-comparison in CropM (see M-C1.1), firstly **objectives and hypothesis to be tested** have been developed:

- evaluate model performance under standardised input and calibration conditions
- identify specific gaps of individual models regarding single processes or crops
- analyse the sensitivity and response of models to various site conditions (e.g. soils, climate, CO_2 etc.) or treatments (e.g. fertilisation, irrigation).
- estimate model uncertainty from the range of results of ensemble modelling
- to test new multi-metric methods for performance assessment
- to test whether single-year calculations or calculation of whole rotation provide better estimations of observed values

Secondly, **the selection of the datasets** has been performed. 5 agricultural datasets were selected and prepared to meet the common protocol for data input and output (Deliverable C1.3). Details on the chosen agricultural datasets can be obtained from Table 1. Fig. 1 shows the distribution of sites across Europe. The datasets are suitable to cover the above mentioned objectives. Data sets will be evaluated using an objective scheme for the classification of suitability for calibration and validation following the MACSUR data classification scheme (Deliverable C1.2). They allow to be splitted into a sub-set for calibration and a sub-set for validation.

Thirdly, the **blind application** was conducted. For this, **basic minimum data sets** derived from the 5 above mentioned datasets were provided in a pre-defined format to modellers (see Deliverable C1.3).

Modelling teams were asked to provide results in a daily and yearly pre-defined output format (see deliverable D.C.1.3.) and pre-defined file names. Further, simulations of the given rotations should be calculated in two separate runs: (1) as single year simulations and (2) as a continuous rotation. However, due to the diverse model architectures, it was not possible for all models to provide model results neither for both variants nor for all crops.

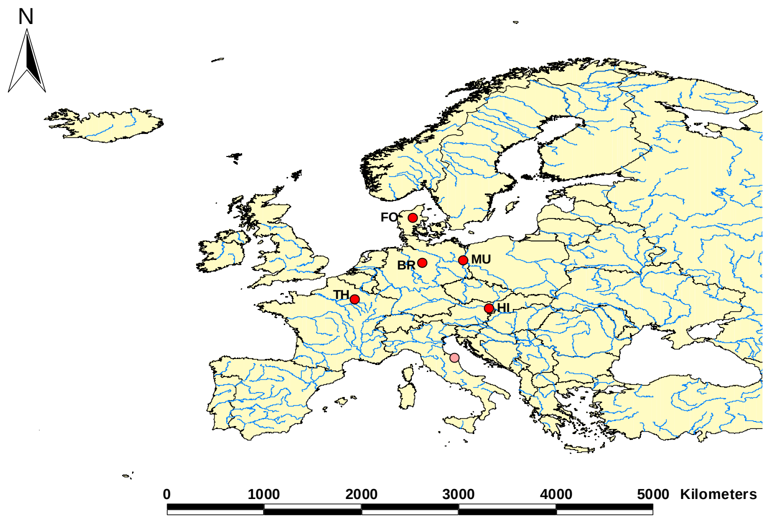

Fig.1 Experimental sites of crop rotations (FO: Foulum, MU: Müncheberg, BR: Braunschweig, TH: Thibie, HI: Hirschstetten)

Table 1: Chraracteristics of the study sites.

Location	Position (latitude / longitude/ altitude	Precipi-tation[a] [mm yr^{-1}]	Tempe-rature[b] [°C]	Soil	Period	Crop rotations	Treatments	Partial calibration
Foulum (DK)	56.49/9.57/ 52 m	670	8.2	Mollic luvisol	2002-2012	BAR/RAP/WHB WHB/GRV/BAR/GRV/PEA/WHB/WHB/BAR/RAD/OAT/WHB/RAD/BAR/RAD/OAT	6 (tillage, rotation, residuals)	Phen/1treat
Müncheberg (DE)	52.52/14.12/62 m	564	8.4	Eutric Cambisol	1992-1998	SBT/WHB/BAR/RYE/RAD	8 (irrigation, inter-annual variability)	Biom/1treat
Braunschweig (DE)	52.3/10.45/ 79m	642	10.0	Sandy loam	1999-2005	BAR/GRV/SBT/WHB	4 (nitrogen level, CO_2)	Phen/4 years
Hirschstetten (AT)	48.2/16.57/ 150m	495	11.0	Fluvisoil/sandy/Tschernozem	1998-2004	MUS/WHB/MUS/BAR/WBH/MUS/POT/WHB/MAZ/WHB	3 (soil)	Phen/1treat
Thibie (F)	48.93/4.23/ 110 m	657	10.9	Haplic Cambisol	1991-2003	PEA/WHB/SBT PEA+GRV/WHB/RAD/SBT/BAR	12 (catch crops, inter-annual variability, nitrogen management)	Phen/1 treat

[a] Average annual precipitation during period of observation.
[b] Average annual temperature during period of observation.
BAR-barley, RAP-rape seed, WHB-wheat, GRV-grass vegetation, PEA-pea, RAD-radish, OAT-oat, RYE-rye, MUS-mustard, POT-potato, MAZ-maize, SBT-sugar beet

Results

All files of modelling results were stored at the site of the main investigators of this study (C. Kollas, K.C. Kersebaum) as well as at the site of the Arhus University data platform. That data platform serves as a storing facility, geo-network and visualisation platform (responsible: Jorgen Olesen, Jens Gronbach Hansen, Sanmohan Baby, see Task C2.2: Database development and management and Task C2.6. Visualisation of Data). The complete dataset encompasses 3366 files. In total 14 modelling teams participated in this first step of the study and each dataset was modelled by 9 teams on average (see Table 2). The number of models capable to reproduce certain crops varied greatly between 3 and 12 (Table 3).

Table 2: Data sets results by model for single year runs (S) and continous (R) runs.

Model	Müncheberg		Braunschweig		Foulum		Hirschstetten		Thibie	
	R	S	R	S	R	S	R	S	R	S
Cropsyst	X	X	X	X	X	X	X	X	X	X
Daisy	X	X	X	X	X	X	X	X	X	X
Fasset	X	X	X	X	X	X	X	X	X	X
Hermes	X	X	X	X	X	X	X	X	X	X
Lintul	X	X	X	X	X	X	O	O	X	X
Monica	X	X	X	X	X	X	O	O	O	O
Stics	X	X	X	X	X	X	X	X	X	X
Swim	X	O	X	O	O	O	O	O	O	O
Theseus	X	O	X	O	X	O	X	O	O	O
DSSAT (Tr)	O	X	O	X	O	X	O	X	O	X
Wofost	O	X	O	O	O	O	O	O	O	O
DSSAT (Ve)	O	X	O	X	O	O	O	O	O	O
LPJguess	O	X	O	X	O	X	O	X	O	X
Spacsys	X	X	X	X	X	X	X	X	X	X
Σ	10	12	10	11	9	10	8	8	7	9

Table 3: Number of models providing results for individual crops from single (S) or continuous (R) runs, number of seasons simulated

	No. of models		No. of total seasons simulated	
crop	R	S	R	S
Wheat	9	12	737	956
Barley	9	11	358	428
Rye	9	9	102	108
Maize	6	7	16	21
Sugar beet	9	9	448	465
Potatoes	6	6	18	18
Rape seed	7	7	70	74
Pea	6	8	301	360
Oat	6	7	48	55
Mustard	4	3	33	27
Oil raddish	7	6	256	271
Gras	7	8	104	140

First results were provided at the MACSUR meetings in Oslo and Sassari. They indicated slightly better results with lower RMSE between observed and simulated crop yields for the continuous runs compared to the single year runs. However, distinct differences regarding model performance exist between the different crops showing that cereals are usually better simulated than tuber/beet crops. Regarding the treatment effects irrigation, nitrogen supply and catch crops as well as atmospheric CO_2 concentration showed stronger effects than tillage and crop residue management.

Discussion

The result files provided by the various modelling teams have been checked for right formatting and consistency. Feedback to the modellers has been sent as pdf files showing the specific modelling team's results highlighted among all results. First results have been produced and presented at meetings in Oslo and Sassari. As discussed at the meetings in Oslo and Sassari it would be desirable to have one additional data set from Southern Europe, because carry over effects from one season to another might be more pronounced under dryer climate conditions. Three data sets from Italy are presently analyzed to check their suitability for the model exercise.

How far a badly simulated crop within the rotation affects the performance of the following crop will be investigated in the second step where more detailed data will be provided for a better calibration especially of the weakly modelled crops. A draft for a first paper analyzing the uncalibrated results is in preparation.

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