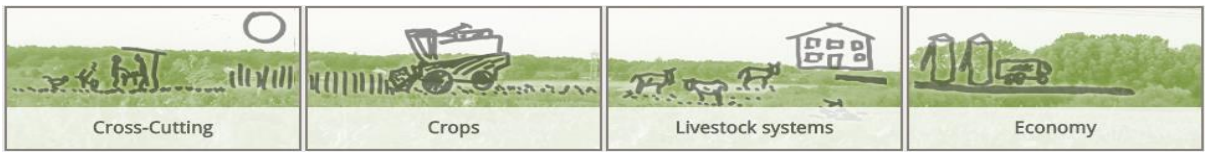
Book of Abstracts

MACSUR2017 Scientific Conference
22-24 May, 2017
Berlin



Presentations of the Keynote Speakers

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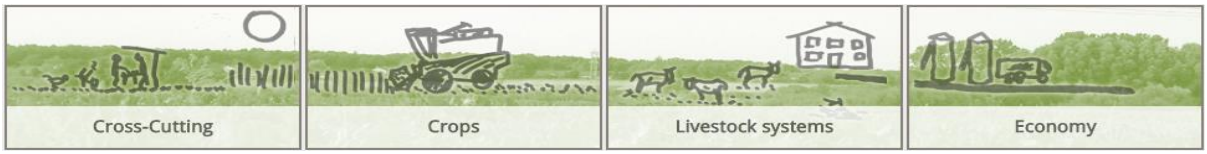

Topic: Agriculture, Climate Change and Food Security
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Agriculture, climate change and food security – progress and challenges in systems research and integrated assessment and modelling

F.A. Ewert

Agriculture, climate change and food security are topics of high societal relevance and have been addressed within the Knowledge Hub MACSUR between 2012 and 2017. Substantial progress has been made in the modelling and assessment for parts of the agri-food system affecting and being affected by climate change with MACSUR. The paper aims to review this progress within the context of international research activities in this field of research and points to key challenges that require attention for future work.

MACSUR has developed from its initial focus in the first project phase on thematic research for the improvement of crop, livestock and agricultural economic modelling towards more integrated assessment and modelling approaches including stakeholder interactions in the second phase. Selected highlights of this research are presented. Particular emphasis is given to activities that successfully filled research gaps and advanced understanding of the agri-food system in interaction with climate change. Links to important international research projects such as AgMIP (Agricultural Model Intercomparison and Improvement Project) and cross-benefits of such interactions are pointed out. Reference is also made to the impact and valorisation of MACSUR research as evident from the diverse forms of outputs and impacts in the scientific literature, on other research projects, on policy-making and beyond.

Achievements of MACSUR are contrasted with recent developments in other sectors and the society affecting agriculture such as international political agreements (for example the United Nations Sustainable Development Goals and the Climate Conference COP 21 in Paris in 2015), new technologies (for example remote sensing, ICT and robotics), changes in the food retailing sector and the development of the bioeconomy. Emerging challenges for agriculture are highlighted and new research topics are identified. The important role of and demands for integrated assessment and modelling to support this development are determined and conclusions for future activities of MACSUR are drawn.

Topic: Projecting climate change impacts on agriculture in European regions
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Multi-scale Modelling of Adapting European Farming Systems.

Banse M, Rötter RP, Dono G, Lehtonen H, Schönhart M, Köchy, M, Zimmermann A

European farming systems are challenged by an increasing global population, income growth, dietary changes and last, but not least, by a changing climate threatening future harvests, especially through increased frequency and severity of extreme events such as drought and heat waves. Therefore, there is a clear need to sustainably intensify and effectively adapt agricultural systems to climate change. Yet, increase in food production and adaptation are just two of many claims on agriculture, which is also supposed to meet growing demands on feed, fibre and fuel and to play a key role in mitigating climate change. The multiple claims on ecosystem services expected from agri-ecological systems call for an integrated assessment and modelling (IAM) of agricultural systems to adequately evaluate the multiple dimensions of the potential impacts as well as promising adaptation and mitigation options. This includes agriculture's responses to global change in the context of other sustainability aspects. Biophysical and socioeconomic analyses need to be integrated across different disciplines and spatiotemporal scales. In recent years the agricultural systems modelling community has made great efforts to use harmonized climate change, socio-economic and agricultural development scenarios and run them through a chain of models, e.g. by selected ensembles of biophysical and economic models at multiple scales, from farm to global. In phase 2 (2015-17) the European MACSUR knowledge hub has put its main focus on the regional (sub-national) level in the EU, with due consideration of the whole farm context.

The aim of this paper is to compare three regional cases from the pool of MACSUR case studies across Europe, i.e. North Savo region in Finland, the Mostviertel region in Austria and the Oristanese region in Sardinia (Italy) representing different European farming systems along a north-south climatic gradient in Europe. These case studies represent a sample of some prominent farming systems, though only a fraction of a much larger diversity of farming and environmental conditions prevailing in Europe. We describe how adaptation options are analysed within an integrated set of linked models or model outputs combining information from different spatial scales, i.e. from region-specific crop, animal and farm level models to an analysis at regional and national level changes in agriculture and food production. First results show that adaptation to climate change affects agricultural production and farm income very differently. For some regions, e.g. in Finland there are both negative and positive effects while for the Sardinian case study adaptation to climate change have negative effects on farm income.

Biophysical models, especially crop simulation models are first applied to analyse climate change impacts on yield, water use, biomass etc. and provide the outputs (i.e. delta changes) as input to economic models that contain the regional specificities of the case studies. Likewise, biophysical

models are applied to analyse effects of various adaptation and mitigation options to provide information on effects of management changes on reducing damage/loss or taking opportunities from climate (adaptation) or reducing greenhouse gas emissions (mitigation). The economic models analyse economic impacts, for example the viability of management changes at farm and regional scales. Farm and regional scale economic models, backed by more detailed data and regional expert knowledge, can supply better representations of developments in each of the regions than this could be done by larger-scale (e.g. EU-wide or global) models. Sector or national economy-wide models are less specific in technical changes in agriculture, productivity changes, or in its use of inputs, due to higher level of aggregation. Nevertheless the market level view offered by sector models put the farm level changes and adaptations in a wider global context. Agricultural markets are highly integrated globally and the analyses for the case study regions also require information on global and European market developments. For example, significant changes in food demand due to changes in tastes and preferences, including aspects of climate change mitigation, may imply major changes for regional production structures. In MACSUR, this information – although not fully implemented in the case studies yet – is provided by the economic agricultural sector model CAPRI. The main strength of CAPRI in this context is that it is a global model with European focus. As such CAPRI can capture global developments and translate them to the regional level in the EU. The coupled analysis using global, EU and national level models side by side with farm level models provides unique results and much more insights on future possibilities and challenges for farmers and the food chain, than separating and restricting the analyses to either low or high aggregation level analyses.

Market and policy changes often dominate longer term climate change considerations in the decision making of food chain actors, even if unfavourable weather events have become more common in recent years. Socio-economic scenarios from global to national and regional levels are needed to put adaptation and mitigation strategies in a wider context. Models, especially those that are able to accommodate biophysical, economic and policy changes are needed to show the value added from adaptations to climate change.

Benefits and costs of mitigation strategies may be highly dependent on market developments. The current integrated assessment and modelling approach of MACSUR focusses on adaptation scenarios. It will be extended for the analysis and impact of mitigation policies in a later phase.

Topic: CropM overview
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CropM overview

M. Bindi 1, F. Ewert 2,3, J.E. Olesen 4, R.P. Rötter 5

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The complexity of climate change impacts and adaptations for managing climate risks and improving food security need more integrated modelling and quantitative assessment approaches that overcome the sole biophysical aspects of crop and cropping systems. Among the modelling tools used to support the decision making and planning in agriculture, crop growth simulation models are most widely applied as they are principally also considered most appropriate for assessments of agricultural impacts of and adaptations to CC .
On this background, in the first phase of MACSUR CropM activities were focused on: (i) crop model inter-comparison and improvement, (ii) data management, (iii) methods of scaling and model linking, (iv) scenario development and impact uncertainty evaluation, (v) capacity building and (vi) the development of methodological case and integrated pilot studies on impact assessment. However, still during the first phase of MACSUR, it became evident that progress on the number of simulated crops, uncertainty propagation related to model parameters and structure, adaptations and scaling were not sufficiently advanced to satisfactorily meet the demands for the assessment of CC impacts on food security. These limitations were considered substantial and applied to different extents to all crop models. Overcoming these limitations required joint efforts, particularly for multi-model ensemble simulations and consideration of novel modelling approaches.
Accordingly, the key challenges of CropM in the second phase of MACSUR were to further advance crop modelling for improved assessment of CC impacts on food security. More specifically, CropM has paid attention in considering ways of improving models to better capture variability and extremes and to evaluate crop rotation modelling using multi-model ensembles (WP C1), performing empirical crop-weather analysis to complement knowledge from dynamic process-based crop modelling (WP C2), to consider management variables in the scaling exercises for different regions (WP C3) as well as the full range of methods for analysing uncertainty and error propagation in climate impact assessments and ex ante evaluation of adaptations, including the use of multi-model ensembles in crop ideotyping for future climates (WP C4). Moreover, both in capacity building (WP C5) and in the cross-cutting activities (WP C6), there has been more emphasis on multi-scale and integrated analysis of adapting to climate change by alternative genotypes (G), management practices (M), systemic changes (e.g. new technologies) and structural changes/transformations of agri-food systems at farm and regional scales.

Topic: TradeM overview
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TradeM overview

Sinabell, F.

The expected economic losses due to climate change are among the most important arguments in order to justify bold measures to reduce the emission of green house gases. TradeM contributed in various ways to a better understanding of both the need of adaptation and the benefits of mitigation measures of agriculture in Europe. The scope of analyses ranged from the continental scale to farm level analyses. Eventually farmers decide about land use the choices on inputs and intensity levels. Results derived from global and national models have therefore be complemented by results from approaches that focus on farms in particular regional contexts and which involve intensive interaction with stakeholders from the primary sector and downstream and upstream industries. Case studies show how TradeM contributed to a better understanding of the nexus between global climatic changes and local adaptation in agriculture which allows to draw conclusions for effective policy making in a world of many uncertainties.

Topic: Climate change – implications for strategies in policy and farming
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Climate change - From an integrated farming perspective.

Martijn Buijsse

Integrated Farm Management (IFM) is a holistic approach characterised by a continuous improvement process in the delivery of more sustainable agriculture. Members of EISA collaborate on this in order to create a united voice for sustainable agriculture and its practical implementation on the ground through the development and promotion of IFM.
In this presentation impacts from integrated farmers who are associated by EISAs national members LEAF (UK) and Skylark (the Netherlands) will be highlighted. What measures do they take, how is the adoption rate, what are the innovations the farmers are working on and how does it work in between these two regions that are characterised as mostly intensive agricultural areas? The main question for debate is whether farming is able to deliver solutions to the aims of the Paris Agreement and what MACSUR can do in order to support the farmers in achieving this.

Topic: Case Study Summary
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Case Study Summary.

In collaboration with Davide Cammarano 1, Tommy Dalgaard 2, Gabriele Dono 3 and Lillian Øygarden 4
1 J Hutton Institute, UK, 2 Aahrus University, DK, 3 Tuscia University, IT; 4 NIBIO, NO

Climate change impacts of agricultural systems are site-specific and adaptive responses are context sensitive. Adaptive plans and actions can emerge from the integration of integrated modelling assessments aimed to assess the cascade of effects from crop production to food security, and stakeholder-based processes, more oriented towards the analyses of capacities and vulnerabilities of the local communities to identify adaptive options. Both approaches are complementary and can provide valuable insights in developing adaptive pathways and strategies at regional and local scale. Depending on the extent of climatic impacts, the adaptive responses were distinguished between incremental (e.g. change planting times), systemic (e.g. change crop) or transformational (e.g. new land uses). Generalized global scale studies can miss to consider the specific regional or local contexts, while approaches based only on the analysis of complex sets of case studies are often difficult to upscale and generalize. The XC6 package of activities within MACSUR, integrated these two approaches in view of contextualizing impact assessments and explore uncertainties to support decision making at different levels. We addressed processes more than goals, assuming that the outcomes of a successful co-design (i.e. between researchers and stakeholders) process will be desirable for those involved. In this presentation, we summarize some of the most significant experiences and lessons learned from more than twenty integrated regional case studies, identified across a wide range of climates, agricultural production systems and expected impacts from climate changes, for which site-specific adaptive responses and strategies must be developed. The activity is framed in the international scientific debate on how to address adaptation challenges for food security and the implications for research and policy developments.

Topic: Climate change – implications for strategies in policy and farming
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Benefits of climate modeling for actors along the food chain - reflections for further engagement between science and practice.

Tania Runge

In the agricultural practice in Europe climate aspects are still rarely influencing decision-making at farm level, other aspects as short- term economics and legislative constraints being more relevant. But also in Europe farmers are facing shifts in weather patterns with weather extremes, thus showing that there is a need for more information regarding climate change. In this regard models which are able to describe climate phenomena and possible options for (pre-)adaptation are becoming more and more valuable for the farming community. This is in particularly relevant for long -term investments like for livestock buildings or irrigation infrastructures, but also for the choice of crops and management practices and related machinery.
At the same time agriculture and in particular the livestock sector is pointed out as an important GHG emitent, in particular for methane. With the Paris agreement, EU Member States are asked to present strategies on how to reduce their emissions. There still is little knowledge about cost-effective measures to reduce emissions at national, and especially at regional and farm level. Here sophisticated, consolidated climate models, able to present possible pathways for emission reductions and in particular its costs can be a very helpful tool for the selection of cost-effective mitigation measures. But in order to have realistic model predictions that are accepted by practitioners, it is important that the scenario- building is done in cooperation with those actors which are in the end asked to base their decisions on them. For the actors along the food chain it is very important not only to get information regarding overall benefits and costs, but at operational level. Still too seldom climate models are used to provide sound information about structural effects induced by climate changes as well as by climate change policies. Another important aspect is the consistency of model outcomes - too often there is heterogeneity in the quantitative as well as in the qualitative model results affecting the trust in agricultural model ing, in particular if not sufficiently explained.
Here MACSUR has already made great progress by aligning scenario definitions and consolidations within and between crop, livestock and trade models, but still much work is necessary to further enforce the dialogue with stakeholders. This is particularly true for possible pathways to reduce livestock emissions without affecting productivity negatively - or even better looking for synergies. Another aspect that should be looked at in more detail are organic soils under agriculture land use and climate and water optimised fertilisation strategies.
Climate models cannot only help farmers and other actors along the food chain, including input and food industries as well as the retail sector to better consider climate aspects in their economic decisions, but are a very powerful tool for decision- makers and for future climate change policies. Here it will become even more relevant in future to address leakage effects.

In Germany, the German farmers' association DBV has started to work on a revised climate strategy for 2030. It is foreseen to identify emission reduction targets and cost-effective pathways. Aspects that will be looked at are, amongst others, fertilisation, manure fermentation and possibilities to increase the soil organic matter content, changes in feeding diets, renewables and land sealing - not only leading to permanent loss of agriculture land, but also affecting micro-climate negatively. The objective is to contribute to the Paris agreement alongside with the SDGs, without disruptive effects in German agriculture.

Oral Presentations of the Parallel Sessions

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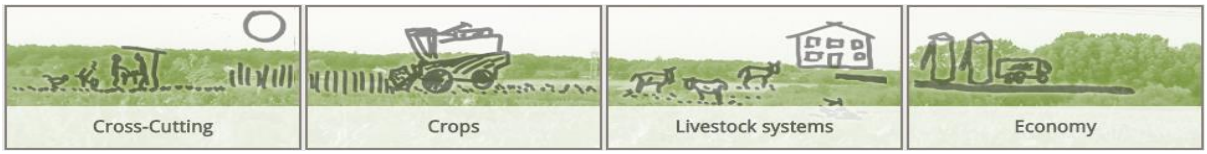

Topic: Improvements in modelling processes, interactions, and feedbacks
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Evaluation of CERES Wheat and Rice Model for changing Climatic Conditions in Haryana, India.

Rana, Mamta, Singh, Dr. K.K. , Kumari , Dr. Nisha

The simulation models with its soil-weather-plant atmosphere interacting system are important tools for assessing the crops in changing climate conditions. The CERES-Wheat & Rice vs. 4.6 DSSAT was calibrated and evaluated for one of major producers of wheat and rice state- Haryana, India. The simulation runs were made under irrigated conditions and three fertilizer applications dose of N-P-K to estimate crop yield and other growth parameters along with phenological development of the crop. The genetic coefficients derived by iteratively manipulating the relevant coefficients that characterize the phenological process of wheat and rice crop to best fit match between the simulated and observed anthesis, physiological maturity and final grain yield.

The model validated by plotting the simulated and remote sensing derived Leaf Area Index (LAI). LAI product from remote sensing provides the edge of spatial, timely and accurate assessment of crop. For validating the yield and yield components, the error percentage between the observed and simulated data was calculated. The analysis shows that the model can be used to simulate crop yield and yield components for selected wheat and rice cultivar under different management practices. During the validation, the error percentage was less than 10%, indicating the utility of the calibrated model for climate risk assessment in the selected region.

Topic: Improvements in modelling processes, interactions, and feedbacks
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Comparing the performance of nutritive value predictions in three timothy models.

Persson, T.1, Höglind, M.1, Van Oijen, M.2, Korhonen P.3, Palosuo, T.3, Jégo, G.4, Virkajärvi, P.3, Bélanger, G.4, Gustavsson, A.-M.5

1. Norwegian Institute of Bioeconomy Research (NIBIO), Særheim, Norway; 2. Centre for Ecology and Hydrology, UK; 3. Natural Resources Institute Finland (Luke), Finland; 4. Agriculture and Agri-Food Canada (AAFC), Québec, Canada; 5. Swedish University of Agricultural Sciences (SLU), Umeå, Sweden

Grasslands are the main source of energy and nutrients in ruminant production systems. Nutritive value of grasslands is in most feeding systems described based on energy, i.e. digestibility and cell wall content, and crude protein content of the feed and plays a significant role in the profitability of these production systems. Timothy (Phleum pratense L.) is a widely used forage grass grown either in pure stands or in mixtures with other forage grasses and legumes in cold-temperate regions of the world. Timothy management practices, including cultivar selection, cutting frequency, and fertilization are adapted to the climate and soil conditions as well as to the animal production system this grass is part of. Models exist that can simulate phenological development, dry matter growth, digestibility and nutritive value of timothy as a function of the weather, soil, and management practices. These models differ in how they represent plant processes related to nutritive value. An analysis of these differences is needed to identify the correct process representation, and requires comparing model outputs against data from experiments conducted under different climate, soil, and management conditions. The overall goal of this study was to compare the ability of three simulation models, BASGRA, CATIMO and STICS, to predict fibre and crude protein concentrations along with digestibility. Datasets covering a wide range of climate and soil conditions, cultivars, and management practices in major timothy grass production regions of Canada, Finland, Norway, and Sweden were used for model calibration and validation. Simulations results were then analysed to better understand the strengths and the weaknesses of the modeling approaches used in the evaluated models.

Topic: Improvements in modelling processes, interactions, and feedbacks
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Implications of input data aggregation on upscaling of soil organic carbon changes.

Grosz, B; Dechow, R; Hoffmann, H; Zhao, G; Constantin, J; Raynal, H; Wallach, D; Coucheney, E ; Lewan, E; Eckersten, H; Specka, X; Kersebaum, K-C; Nendel, C; Kuhnert, M; Yeluripati, J; Haas, E; Klatt, S; Teixeira, E; Bindi, M; Trombi, G; Moriondo, M; Doro, L; Roggero, P, P; Zhao, Z; Wang, E; Tao, F; Rötter, R; Cammarano, D, Asseng, S; Weihermüller, L; Siebert, S; Gaiser, T; Ewert, F

Dynamic process models are increasingly used to predict changes in soil organic carbon (SOC) stocks of agricultural soils on the large scale. This study examines the aggregation effects of climate and soil data on regional SOC modeling for varying simulation periods based on a multi model ensemble. For a NUTS2 region in central Europe (North Rhine-Westphalia) data on soil properties and daily weather available on a spatial resolution of 1 km have been aggregated to 10, 25, 50 and 100 km resolution. Soil data aggregation (DA) showed a bigger effect on modeled SOC stock changes than climate DA, which was one order of magnitude smaller. The DA effect determine the spatial resolution of model output (scale of interest). Model errors, calculated as the difference between respective DA level and 1 km outputs, were high at low model output DA level (scale of interest: 1 km) and decreased with increasing scale of interest (10-100 km). Additionally, a large variability of simulated SOC contents amongst models was observed. Contrary to model errors induced by input DA, this variability was not leveled out by increasing the scale of output data. The regionalization of SOC stocks and changes is highly influenced by input DA. Factors like the length of the modeling period, the modeling region and the type of input DA control the resulting errors. The presented study describe a detail of these relationships.

Acknowledgements
The German Federal Ministry of Food and Agriculture (BMEL) through the Federal Office for Agriculture and Food (BLE), grant number 2851ERA01J, project 'Modelling European Agriculture with Climate Change for Food Security (MACSUR)', the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning, the Faculty of Natural Resources and Agricultural Science

Topic: Improvements in modelling processes, interactions, and feedbacks
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How is crop growth model calibration performed? Results of a survey.

S. J. Seidel, T. Palosuo, P. Thorburn and D. Wallach

Crop growth model calibration, or parameter estimation, is a demanding and critical step of a crop modeling project: Projections from a model are determined by the parameter values used in the model, and parameter uncertainty can play a major role in projection uncertainty. Despite its importance little attention has been paid to the calibration approaches and methods used. An open web-based online survey with 39 questions about crop model calibration was conducted in autumn 2016 aiming to record the current practices in crop model calibration across the crop modeling community.

The sections of the survey related to the data used for calibration, the parameters calibrated, the calibration method and the software used, as well as estimation of the parameter uncertainty. In addition, there were questions providing background information about the model user and model, time required for calibration and challenges faced. Overall, 211 survey submissions were analyzed to examine the common practices in crop model calibration. The respondents covered both more and less experienced modellers with a wide range of models and calibration approaches used.

This talk will present the results of the survey, and what they imply concerning the major choices faced during calibration. An important question asked respondents what they thought was the major challenge of crop model calibration. Only two (out of 211) respondents answered that they saw no major problems. This emphasizes the need for progress in calibration and setting out guidelines of good practices.

Topic: Improvements in modelling processes, interactions, and feedbacks
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Modelling production and environmental impacts of perennial cropping systems with the STICS model.

Strullu, L, Ferchaud, F, Mary, B, Louarn, G, Thiébeau, P, Drochon, S, Beaudoin, N.

The Seventh Environment Action Program of the European commission commits the European Union to "increase efforts to reduce soil erosion and increase organic matter". Use of perennial crops in crop rotation could be a way to meet this objective.

Perennial crops differed from annual crops due to their ability to recycle C and N from one year to another. They could also increase C and N storage in soils due to perennial organs death and root system turn-over. We recently improved the STICS model to allow long term simulation of perennial cropping systems, matching with its objective of genericity for crops (Brisson et al., 1998; 2003). We added to the model new formalisms allowing the simulation of C and N fluxes between perennial and non-perennial organs (Strullu et al., 2014) and the simulation of root system turn-over by distinguishing fine and coarse roots (Strullu et al., 2015).

The model was able to simulate with accuracy biomass production and N content of different perennial crops in various climate and soil conditions. Moreover, taking into account C and N inputs to the soil due to crop residues allowed a realistic simulation of the evolution of soil organic carbon and nitrogen (SOC and SON respectively).

We realized a sensitivity analysis of the evolution of SOC, SON and mineral N in the soil to C and N inputs due to crop residues quantity and quality. Results highlighted the primary role of roots and perennial organs turn-over on C and N storage in soil.

Improvements brought to the model allow the simulation on the long term of perennial cropping systems biomass production and environmental impacts. These modifications will also be useful to simulate alternative cropping systems.

Acknowledgements: This research project received funding from ACVF through project VariLuz

Topic: Improvements in modelling processes, interactions, and feedbacks
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Watch It Grow, an innovative platform for a sustainable growth of the Belgian potato production.

Curnel, Y., V. Planchon, A. Le Clef, I. Piccard, A. Gobin, J. Wellens, N. Cattoor, R. Cools, J.P. Goffart

Belgium is the largest exporter of frozen potato products in the world. Each year, Belgian companies process over four million tons of potatoes into French fries, potato chips and other products. To ensure a sustainable growth of the potato sector, a higher potato production is needed. In this context, expansion of agricultural land is not an option.

Potato processors, traders and packers largely work with potato contracts. The close follow up of contracted parcels is important to improve the quantity and quality of the crop and reduce risks related to storage, packaging or processing. The use of geo-information by the sector is limited, notwithstanding the great benefits that this type of information may offer. At the same time, new sensor-based technologies continue to gain importance and farmers increasingly invest in these technologies.

The combination of geo-information and crop modelling might strengthen the competitiveness of the Belgian potato chain in a global market.

In the frame of the iPot project, financed by the Belgian Science Policy Office (BELSPO), a commercial webtool called Watch iT Grow helping potato traders, the processing industry as well as farmers to monitor the potato growth has been developed.
By using weather data, satellite images, aerial images (taken with drones) and data from ground measurements, users are for instance able to follow whether the crops emerge properly from the ground, how the growth is developing, whether diseases might be present or when farmers can start harvesting. The collected data are combined into crop growth models allowing the webtool to propose as well yields estimations and predictions per plot.

Topic: Improvements in modelling processes, interactions, and feedbacks
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Does collaborative farm-scale modelling address current challenges and future opportunities?

Hutchings, Nicholas

Historically, farm-scale models have tended to be created, owned and maintained by a single person or research organisation. This modus operandi is proving increasingly fragile, when confronted with budgetary constraints and staff turnover. At the same time, rapid developments in sensors and communication technology mean that there are increasingly opportunities for data acquisition relating to farm-scale activities; data that could enable models to be parameterised for individual farms. Collaborative modelling is proving to be a viable alternative that has numerous advantages; it accesses a wider range of expertise – particularly relevant for farms with livestock, manure management systems and a range of crops, it allows costs to be shared, buffers budget and staff changes in individual organisations, increases quality control of model code and extends the biophysical and management dimensions of model testing. However, collaborative modelling itself presents practical and cultural challenges that must be overcome and also imposes some costs. The practical challenges include agreeing the choice of computing language (and often operating system), the need to develop QA/QC procedures and agreeing how costs should be shared. The cultural challenges include the need for research organisations to acknowledge the necessity of joint ownership of a flagship activity and for modellers to agree common quality criteria, and the willingness to accept criticism that this implies. We here reflect on the experience garnered through the development of two modelling platforms and assess their role in determining the future course of farm-scale modelling.

Topic: Improvements in modelling processes, interactions, and feedbacks
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Process-based modelling of the nutritive value of forages: a review.

Virkajärvi P., Korhonen P. , Bellocchi G., Curnel Y., Wu L., Jégo G., Persson T., Höglind M., Van Oijen M., Gustavsson A.-M., Kipling R.P., Rotz A., Palosuo T., Calanca P.

Modelling sward nutritional value (NV) is of particular importance to understand the interactions between grasslands, livestock production, environment and climate-related impacts. Variables describing nutritive value vary significantly between ruminant production systems, but two types are commonly used: 1) variables related to cell wall content, digestibility and energy, and 2) variables related to protein content.

This study reviews and compares alternative modelling approaches simulating forage NV. It is intended to: 1) provide model users essential information for a fit-purpose use of grassland models; 2) give model builders feedback helpful in improving the models; 3) promote the development of state-of-the-art model assessment. The focus is on approaches applicable for European grasslands, as implemented in the grassland models; BASGRA, CATIMO, IFSM, MCPy, ModVege, PaSim, QUAL, SPACSYS, and STICS. These models cover swards cut for silage or hay, grazed swards, monocultures and mixtures, permanent grasslands and leys kept for less than five years.

Six out of nine models use neutral detergent fibre (NDF) to describe content of structural carbohydrates. Digestibility of harvested dry matter (DM) is estimated as a function of NDF content and NDF digestibility in five models. Two of the models use an alternative approach that consists in estimating organic matter digestibility or in-vitro true digestibility of DM directly. Three of the models include variables to describe net energy content of DM whereas one model use metabolizable energy. To estimate protein value of harvested DM seven approaches use crude protein concentration calculated as a function of plant nitrogen concentration and one model uses digestible intestinal protein content.

Topic: Improvements in modelling processes, interactions, and feedbacks
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Modelling the impact of rural frontier migration on tropical deforestation.

Anton Van Rompaey, Niels Debonne, Matthias Vanmaercke

A major driver of tropical deforestation is rural frontier migration. In this paper an attempt is made to formally describe the human-environment interactions that are manifested in a forested system experiencing a large influx of rural migrants. The Guraferda district in South-West Ethiopia was selected as an exemplary case-study. On the basis of an extensive field surveys in several villages, the relation different social groups in the area were identified: the native population, recent immigrants and investors. For each of these groups their livelihood and their relation with the forest resources was analyzed on the basis of interviews and mapped via remote sensing. To formalize the identified human-environment interactions, an agent-based model was developed. The model simulates the decision-making process concerning deforestation of the identified agent types. The native population consists of shifting cultivators, while the new immigrants are technologically more advanced and are sedentary farmers. For each grid cell of the landscape, utilities for the agent types are calculated. High potential yields increase utility, while proneness to diseases, high population density and the presence of forest decrease utility. Learning behavior is implemented, allowing native agents to learn from migrants and vice versa, thus increasing productivity. Agricultural investors are added to the model as a passive agent type that can grab land from the previous two groups. Results show that immigration started with the forced resettlements in 1985, after which voluntary migrants followed in great number thereby pushing the native population to new frontiers. Ongoing land grabbing by external investors is accelerating this process.

Topic: Improvements in modelling processes, interactions, and feedbacks
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Modelling the impact of soil management on soil functions.

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Soil is the central resource for the production of biomass and due to an increasing soil loss and an increasing demand for food and energy there is an enormous pressure on soils. Besides the importance of soils for biomass production there are other essential soil functions we would like to preserve. To render agricultural production efficient and sustainable we need to develop model tools that are capable of quantitatively predict the impact of a multitude of management measures on soil productivity and soil functions.
These functions are considered as emergent properties produced by soils as complex systems. The major challenge is to handle the multitude of physical, chemical and biological processes interacting in a non-linear manner. There is a large number of validated models for specific soil processes. However, it is not possible to simulate soil functions by coupling all the relevant processes at the detailed (i.e. molecular) level where they are well understood. A new systems perspective is required to evaluate the ensemble of soil functions and their sensitivity to external forcing. A second challenge is that soils are spatially heterogeneous systems by nature. Soil processes are highly dependent on the local soil properties and, hence, any model to predict soil functions needs to account for the site specific conditions.
We propose a new model strategy based on a thorough analysis of the interactions between physical, chemical and biological processes considering their site-specific characteristics. Coupling of the observed nonlinear interactions may define the stability and the sensitivity of the systems with respect to soil productivity and soil functions. The presented approach has been developed in the framework of the BonaRes project funded by the German Ministry of Education and Research.

Topic: Climate change adaptation and mitigation at the farm scale
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Rethinking farm-scale modelling to meet new challenges and possibilities.

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Historically, agricultural models have tended to be created, owned and maintained by a single person or research organisation. This modus operandi is often proving fragile, when confronted with budget constraints and staff turnover. Collaborative modelling is proving to be a viable alternative that has numerous advantages; it allows costs to be shared, buffers budget and staff changes in individual organisations, increases quality control of model code and extends the biophysical and management dimensions of model testing. However, collaborative modelling itself presents practical and cultural challenges that must be overcome and also imposes some costs. We here reflect on the experience garnered through the development of two modelling platforms: APSIM and RECORD.

Topic: Improvements in modelling processes, interactions, and feedbacks
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Observed Crop-Yield Response Economic and Agro-climatic Factors in Austria - a Spatial Analysis.

Marton, T.; Pennerstorfer, D.; Sinabell, F.

The purpose of this study is to investigate empirically the effects of agro-climatic factors, economic incentives and farmers' land-choice on crop yield responses. We focus on soy bean and maize yields observed in Austrian municipalities over the past 14 years.
Weather events, economic factors and technology are the driving forces behind the evolution of annual average yields. In the literature crop yields are frequently derived from crop models or from experimental stations or from reports of farmers (e.g. farm accountancy data network FADN). The data we use are obtained from the statistical services. Our approach therefore differs from studies on crop models or contributions based on data of experimental stations, as we focus on economic outcomes (yield of farmers) and explicitly take economic variables (e.g. market prices) into account.

The exact relationship between factors affecting crop yields is not yet well understood due to the complexity of the measurement and definition of weather variables as well as the great variety of technological and managerial factors. Many variables influencing crop yield (weather or soil condition) exhibit a pronounced spatial structure, and therefore yields are spatially correlated as well. We account for this potential bias by applying spatial panel models in order to improve the efficiency of the models explaining variation of yields over time and space.

Our results show that the effects of weather conditions are statistically significant and economically sizable. However, we can also show that non-spatial models tend to overestimate the parameter estimates of the respective explanatory variables. We conclude that it is advisable to explicitly control for spatial effects in crop yield response studies which are based on observed crop yields.

Topic: Improvements in modelling processes, interactions, and feedbacks
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Modelling plant disease and pest effects on crop performances.

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Modelling the effects of plant diseases and pests on crop performance, starting with crop yield, is an important new challenge MACSUR wants to address. We have established a small "Pest and Disease" group within MACSUR, where we address this question, with particular emphasis on wheat and grapevine. In the case of wheat, a reference data set from Denmark is being used as a key reference set for wheat - septoria tritici blotch - leaf rust interaction. In a first step an ensemble of seven wheat growth models of different complexity implement defined mechanisms for damages through pest and diseases using field data of a "pest-free" treatment for crop model calibration and idealised (temporal) patterns of injuries represented by simplified disease progress curves. In a second step field data of non-protected field plots are provided together with disease severity data to test simulations of real disease effects on crop yield loss against observed data. In parallel, we collected information on available data for pest and disease impacts by a questionnaire to evaluate their suitability for crop growth as well as for pest and disease modelling. We shall report our results in this exercise, and outline the approach we envision to (i) continue this work on wheat, and (ii) expand it to other crops such as grapevine.

Topic: Improvements in modelling processes, interactions, and feedbacks
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Comparing the site sensitivity of crop models using spatially variable field data from precision agriculture.

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Impacts of climate change on crop production depend strongly on the site conditions and properties. Vulnerability of crop production to changing climate conditions is highly determined by the ability of the site to buffer periods of adverse climatic situations like water scarcity or excessive rainfall. Therefore, the capability of models to reflect crop responses and water and nutrient dynamics under different site conditions is essential to assess climate impact on a regional scale. To test and improve sensitivity of models to various site properties such as soil variability and hydrological boundary conditions, spatial variable data sets from precision farming of two fields in Germany and Italy were provided to modelers. For the German 20 ha field soil and management data for 60 grid points for 3 years (2 years wheat, 1 year triticale) were provided. For the Italian field (12 ha) information for 100 grid points were available for three growing seasons of durum wheat. Only key phenological stages and the highest crop yield within the field for one year were provided for a basic calibration. Modelers were asked to run their models a) using the model specific standard procedure to estimate soil hydraulic properties from texture and b) using fixed values for field capacity and wilting point derived from soil taxonomy and c) using information for all grid points of the first year (yield, soil water and mineral N content for Germany, yield, biomass and LAI for Italy). Results of twelve models are compared against measured state variables analyzing their site response and consistency across crop and soil variables.

Topic: Improvements in modelling processes, interactions, and feedbacks
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Comparison of two calibration levels on the simulation of soil water content using nine crop models under different rotation schemes in five European sites.

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Diversification of crop rotations is a basic agronomic practice recommended to increase the resilience of agroecosystems, especially in a context of climate change. The majority of crop simulation studies have focused in simulating single crops during singles years. In a long term perspective, it makes more sense to simulate rotations than single crops because they can also characterize the carry-over effects of the previous crop, providing much better arguments for impact and adaptation studies.

The aim of this study is to compare two levels of crop model calibration on the projections of soil water availability using nine different crop models (using rotation and single year simulations) in five sites and under different rotation schemes. The low calibration level contained only information related to soil water content and soil mineral N at a date close to sowing day. High calibration contained detailed information about soil parameters, management, so as plant phenology. Data sets from five European sites including ten crops under different crop rotation schemes were used. The targeted variable was soil water content during different periods along the crop season.

Results indicate that, for the majority of crops, the high calibration does improve the modelling performance of the dynamics of soil water content for all models when compared with low calibration. When comparing models using rotation or single year simulation, it could be perceived that rotation models can better mimic the long term dynamics of soil water availability. Site conditions also play a role in the quality of the simulation. Overall, models capable of simulating rotation schemes perform better than single year models, if the objective is to assess the soil water dynamic in long term.

Topic: Improvements in modelling processes, interactions, and feedbacks
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Effects of grassland management on the global carbon cycle.

Rolinski, S., C. Müller, J. Heinke

In global dynamic vegetation models such as LPJmL, usually management on grassland is represented by rather simple assumptions. These aim e.g. at the inclusion of a harvesting mode that reduces leaf biomass and ensures productivity dependent biomass removal. This management is mostly not ideal, i.e. maximizing harvest (as implemented in LPJmL default) without ensuring livestock feed for the vegetation period or avoiding soil carbon loss. Apart from assessments of the effects of homogeneously distributed managed options, investigations of currently applied management can help to find out which grass harvesting options could be favoured for sustainable intensification of grassland.
Using a global dataset of grassland management (Chang et al., 2016, Biogeosciences) in combination with the dataset of the livestock density distribution (Herrero et al., 2013, PNAS), current carbon fluxes and pools on grassland are investigated using LPJmL with grassland management options (Rolinski et al., submitted to GMD). Here, feedbacks of harvesting aboveground grass biomass on productivity (NPP) and soil carbon development are quantified especially for intensively used pasture in Europe.

Topic: Improvements in modelling processes, interactions, and feedbacks
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Modelling of carbon cycle in grassland ecosystems of diverse water availability using Biome-BGCMuSo.

Lellei-Kovács E., Barcza Z., Hidy D., Horváth F., Ónodi G., Kertész M.

Grassland ecosystems have an important role in agriculture, and at the same time, are highly sensitive to changes in land use and climate change. Simulation of the biogeochemical cycles of managed grasslands may help in identifying and quantifying the main processes contributing to changes in their productivity. In our work we used the latest version of Biome-BGCMuSo model, the modified version of the widely used biogeochemical Biome-BGC model, with structural improvements to simulate herbaceous ecosystem carbon and water cycles more faithfully.
Our sampling areas were in diverse grasslands in the Kiskunság, Hungary. Different soil texture and changing water table level, consequently highly different water conditions are characteristic in these ecosystems, influencing the development and productivity of vegetation, and also the potential for animal husbandry. Hence, for the meadows and the marshland ecosystems we included mowing management in the simulations. In order to compare the ecosystems and study their functions we simulated ecosystem variables, such as ecosystem respiration, standing and harvested aboveground biomass etc.
We found that ecosystems with higher water availability are more sensitive to changes in water conditions, and their productivity is more variable between years. By calibration processes using leaf area and aboveground biomass we aim to further specify our findings.
Biome-BGCMuSo is available as a standalone model, but also through virtual laboratory environment and Biome-BGC Projects database (http://ecos.okologia.mta.hu/bbgcdb) developed within the BioVeL project (http://www.biovel.eu). Scientific workflow management, web service and desktop grid technology can support model optimization in the so-called „calibrated runs" within MACSUR.

Topic: Improvements in modelling processes, interactions, and feedbacks
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Modelling climate change adaptation in European agriculture: Challenges and priorities.

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Climate change presents major challenges for European agriculture, and the speed, nature and extent of the responses to such challenges will have far-reaching social, economic and environmental consequences. Agricultural modelling has an important role in helping decision makers better understand the costs and benefits of different adaptation strategies, as well as trade-offs and win-wins between those strategies, mitigation measures and other economic, social and environmental goals. Incorporating adaptation strategies into biophysical, bio-economic and economic model is essential to gaining a more holistic understanding of their impacts, beyond the context of specific changes and purposes. Here, the ability and potential of agricultural models to characterise different adaptation strategies was explored, using the expertise represented within the Modelling European Agriculture with Climate Change for Food Security (MACSUR) project. In two workshops, modellers identified adaptation strategies, modelling challenges and knowledge gaps. A survey was conducted to understand current

modelling capacity. Challenges centred on knowledge gaps, data availability, technical issues, and stakeholder interaction (e.g. communication with, relevance for). For operational and tactical strategies (changes in practice in response to daily, monthly, or seasonal variation in conditions) most challenges were technical, relating to limitations in the processes and mechanisms represented in models. For longer term strategic climate change adaptation, uncertainty about future socio-economic context (e.g. prices and regulation) and the impact of new adaptation options (e.g. appearance of new technologies) were highlighted. Progressively novel and far-reaching strategies increasingly challenge the scope of existing models. Whilst models vary in capacity, most modellers reported a potential to better characterise adaptation. However, costs (e.g. trade-offs with processing speed) and the fact that adaptation lies beyond the initial remit of many models mean that strategic prioritisation of adaptation as a focus for modelling is key to facilitating model development to support effective stakeholder choices.

Topic: Advances in linking models in order to address impacts across scales or sectors
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Wanting it all - is a stakeholders' Vision for Europe compatible with meeting Europe's food demand under climate change?

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Responding to climate change requires a desirable endpoint or vision against which to plan adaptation and mitigation and to determine `success'. Climate change impact, adaptation and vulnerability (CCIAV) models are useful tools to assess the consequences of adaptation in reducing the potential impacts of climate change. However, to date most CCIAV studies have had two significant limitations - (1) the lack of a clearly defined Vision and (2) a lack of contextualisation of adaptation according to the constraints (and opportunities) of alternative socio-economic futures. This paper describes how a European integrated assessment platform (the IMPRESSIONS integrated assessment platform or IAP), downscaled European Shared Socio-economic Pathways (Euro-SSPs) and a structured stakeholder engagement process of adaptation planning and Visioning have been brought together to provide a rich understanding of the adaptation challenges facing Europe. A scenario-neutral multi-dimensional Vision for Europe in 2100 (encapsulating such factors as equity, lifestyle, governance, resilience, environment, food, water and energy) was derived by stakeholders, who then developed preliminary adaptation, mitigation and transformational pathways to achieve the Vision within the context of the individual Euro-SSPs. The multi-sectoral IMPRESSIONS IAP was then used to assess the ability of the pathways to achieve selected indicators of the Vision. The results demonstrate the very different challenges and opportunities for Europe over the coming century posed by the Euro-SSPs and the synergies and trade-offs between meeting Europe's food demand under climate change and other desirable aspects of the Vision.

Topic: Advances in linking models in order to address impacts across scales or sectors
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Integrated Impact Modelling of climate change and adaptation policies on land use and water resources in Austria.

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Climate change is a major driver of land use and ecosystems. Changes in climatic conditions will affect the quality and quantity of water resources. Autonomous adaptation by farmers can influence the compliance with the good ecological and chemical status according to the EU Water Framework Directive. We present results from an integrated impact modelling framework (IIMF) to analyze policy options for planned adaptation in agricultural land use and sustainable management of land and water resources until 2040. The IIMF consists of the bio-physical process model EPIC, the regional land use optimization model PASMA[grid], the quantitative precipitation/runoff TUW model, and the surface water emission model MONERIS. Stakeholder driven scenarios facilitate multi-actor knowledge transfer. Climate change scenarios are combined with socio-economic and policy pathways. The latter include water protection measures on fertilization management, soil and crop rotation management. The results show that the selected climate change and policy scenarios impact average agricultural gross margins by ±2%. However, regional impacts are more severe particularly under assumptions of decreasing precipitation patterns. The water protection policies can alleviate pressures compared to the business as usual scenario but do not lead to sufficient conditions in all watersheds. To conclude, the IIMF is able to capture the interfaces between water quality and land use and to cover multiple policy and climate scenarios. However, despite efforts to increase the robustness of data and model interfaces, uncertainties need to be tackled in subsequent studies.

Topic: Advances in linking models in order to address impacts across scales or sectors
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Climate-neutralizing managed landscapes in Sweden.

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To limit dangerous climate change, Sweden has signed a law to contribute zero net greenhouse gas (GHG) emissions to the atmosphere. Land use is an important source of Sweden's emissions, but it can also be managed to take up more CO2 in growing vegetation and increase carbon storage in soils, thus reducing climate warming. We will present results from our project, modeling the factors controlling the GHG balance of farms and forests to support Sweden achieving its climate goals in an environmentally, socially, and economically optimal way.

We will use the ecosystem model LPJ-GUESS (Olin et al., 2015) to identify different combinations of land use (e.g., forest vs. agriculture) and land management (e.g., agricultural intensity) that could achieve this multi-dimensional aim. The identified land-use and land-management combinations will be evaluated relative to the current landscape for their ability to sequester carbon and nitrogen, produce food and timber, and preserve cultural landscape values. We will also evaluate the consequences for land managers' incomes and societal welfare.

Different ecosystem services are measured in different units and thus trade-offs between them cannot be evaluated directly, all services will be valued for their marginal contributions to societal welfare using market and non-market valuation techniques. We expect to show significant trade-offs among the climate goal and other ecosystem services; hence societal welfare can only be maximized by identifying optimal trade-offs among ecosystem services given the climate goal.
We will present this novel framework that combines quantification and valuation of multiple ecosystem services to identify optimal climate pathways for Sweden and discuss the potential to extend this approach for Europe.

Topic: Advances in linking models in order to address impacts across scales or sectors
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Sustainable agricultural intensification: indicators and metrics for multi-scale modeling.

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Agricultural production is expected to provide food security, respect the environment, sustain rural communities and cover an increasing demand for the bioeconomy. In order to simultaneously address these objectives, sustainable agricultural intensification is seen as a promising strategy that could allow satisfying growing demands for agricultural food and non-food products, while reducing environmental impacts and maximizing resource use efficiency. However, the quantification and ex ante evaluation of sustainable intensification options and their associated trade-offs with respect to the various sustainability dimensions remain a challenge.

This study aims to address this challenge by presenting a framework for measuring sustainable intensification. First, we reviewed literature on sustainability criteria for agriculture, biomass and bioenergy production, and metrics and frameworks for measuring sustainable intensification. Second, we developed a framework for quantifying sustainable intensification via transparent, clear and relevant indicators that allow the analysis and weighing of trade-offs across sustainable intensification options and scales. Third, we contrasted the metrics of the developed framework to typical outputs of a number of biophysical and economic models of agricultural systems, across different scales including the field, farm, regional, EU and global levels, in order to evaluate typical modeling capabilities to quantify sustainable intensification.

This talk will present the findings of this exercise, demonstrate the operationalization of the framework for the assessment of the dual production of food and non-food products, and propose an approach for further improving the presented sustainable intensification metrics via stakeholder involvement.

Topic: Advances in linking models in order to address impacts across scales or sectors
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Assessing priorities for enhancing adaptive capacity of agricultural systems to climate change using fuzzy logic-based approaches.

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This study outlines the development of a composite indicator of the adaptive capacity (ACI) to climate change of rural communities in the Oristanese district (Sardinia, Italy). Farming systems include intensive dairy cattle, rainfed dairy sheep, cereals and irrigated horticulture. Twenty-one indicators of AC were derived from an array of several priorities, initially identified by an interdisciplinary team of scientists and then extended and scored (on a rank from 1 to 5) by 31 experts (agronomic scientists, farmers, advisors and consumers). The extended list of priorities was reduced to a set of indicators that could be quantified using data from different sources. The indicators were organized into seven determinants (Infrastructure, Technology, Economic power, Flexibility, Knowledge, Sensitivity, Social capital), in turn organized in three components: Ability, Action and Awareness. AC calculations required that 1) scores for each basic indicator be normalized and aggregated to a determinant value, 2) determinants aggregated to a component value, 3) components aggregated to an AIC (best, 0≤ACI≤1, worst). A fuzzy logic inferring system was used based on the importance of the basic indicators and their aggregation into determinants and components. Favourable/unfavourable thresholds for each indicator were set following expert knowledge and/or survey/census/literature data, while the priority scores were used to assign weighting factors. Results for the Oristanese district indicate a low-medium AC (ACI=0.61) with social capital (0.27) being the strongest determinant and economic power (0.80) the weakest. These findings provide insights for enhancing effective, locally meaningful and feasible strategies by increasing the AC of Oristanese rural communities.

Topic: Advances in linking models in order to address impacts across scales or sectors
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Assessment of soil and climate change data aggregation impact on crop yield simulation: from local to regional study in NRW, Germany.

Maharjan, GR., H. Webber, H. Hoffmann, F. Ewert, T. Gaiser

The soil and historic climate data aggregated at different scale has been applied in crop models to quantify aggregation impact on yield simulation and other model output variables in past studies. Here we have evaluated the aggregation effect of soil and future climate data sets (12 GCM - RCP scenarios) on yield simulation for the period of 2040-2070 and 2070-2100. The climate change data sets for North Rhine-Westphalia (NRW), Germany were spatially aggregated from 25 km grid cells to 50 km and 100 km. In contrast, the soil data for NRW was aggregated from 1km by selecting dominant soil type within the respective coarser grid cells (25 km, 50 km and 100 km). We have applied SIMPLACE, a crop modelling platform to simulate crop yield for winter wheat under water limited condition for all climate change scenarios. We found that the use of aggregated soil and climate change data at 50 km and 100 km resolutions resulted in simulated yield (winter wheat) differences from -6 to +4 ton ha-1 compared to simulated yields using input data of higher resolution (25 km). Therefore, the application of input data at coarser resolution (50 km and 100 km) has considerable impact on simulated yields at local level. In contrast, at the regional level for entire NRW, with input data (soil and climate) aggregated at 50 and 100 km the mean absolute simulated yield differences (bias) compared to 25 km (highest resolution data) were less than 2 ton ha-1. In addition, we found the annual variability of simulated yield was not significantly influenced by input data aggregated at coarser resolution. However, the impact assessment of aggregated data on yield simulation for other crops and regions by ensemble crop models could provide different range of aggregation effects than this study.

Topic: Advances in linking models in order to address impacts across scales or sectors
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Recent advances in integrated assessments of climate change impacts on European agriculture.

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The broad EU public expects agriculture to improve global food security, protect the environment and sustain rural communities and landscapes. Agricultural policy makers must additionally consider resource scarcity and degradation, loss of biodiversity, climate change adaptation and, increasingly, mitigation. Integrated assessment modelling (IAM) can simultaneously consider key agricultural drivers and the main economic and environmental outcomes in identifying opportunities and balancing trade-offs for EU agriculture in the future. In this review of recent and on-going European scale IAM studies, results are synthesized to quantify the range of uncertainty for key impact variables. Explicit attention is given to the drivers (climate change, socio-economic scenarios, technological) and adaptations considered, their relative importance across impact variables, feedbacks and cross-scale linkages. Crop management adaptations, widely demonstrated in regional studies, were found to have a large effect on crop yields as simulated with crop models, with relatively less influence on simulated economic variables. The few studies to simultaneously consider climate change and technological development, found yield trends offset yield losses due to climate change and be more important than adaptation. The MACSUR Coordinate Global and Regional Assessment (CGRA) seeks to explicitly model yields trends with crop models, partnering with the Global Yield Gap Atlas (GYGA) to understand the relative contribution of management and breeding to past trends. Examples of heat and drought risk analysis with crop models are presented, though their consideration in economic studies remains limited. Finally, opportunities are identified for cross-scale analysis and assessment within MACSUR.

Topic: Advances in linking models in order to address impacts across scales or sectors
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Assessing the Importance of Accounting for the Impacts of Global Climate Change on Relative Competitiveness and International Trade in the Agricultural Sector.

Beach, R., P. Havlik, J. Baker, and H. Valin

Climate change is expected to cause substantial changes in agricultural productivity across the globe. Because the impacts will differ between crops, production practices, and regions, there will be changes in the relative profitability of alternative land uses and effects on the relative competitiveness of production in different countries. However, many previous studies have focused on climate change impacts in one country or region without explicitly assessing the importance of impacts on the rest of the world in determining the net impacts on the focus country or region. Even when they include endogenous trade flows, domestic partial equilibrium models generally do not capture productivity changes in the rest of the world in detail and therefore do not adequately address impacts on relative competitiveness, international trade, and global markets and associated food security outcomes. In this study, we apply the GLObal BIOsphere Model (GLOBIOM), which is a detailed global partial equilibrium model of agriculture, forestry, and bioenergy to evaluate the relative contribution of direct climate change impacts on agriculture occurring within a country vs. those taking place in the rest of the world. We run a set of scenarios for multiple major agricultural regions comparing the outcomes when climate impacts are applied only to that region relative to applied to all regions of the world, using multiple climate scenarios and alternative assumptions regarding trade flexibility. This enables us to compare the relative importance of accounting for impacts outside the country of interest and the extent to which the relative impacts differ for developing vs. developed countries as well as for major commodity exporters vs. importers.

Topic: Addressing uncertainty and risk in climate change impact studies
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Increasing wheat yield potential and stability under climate change will require tolerance to drought during reproductive development.

Semenov M.A., Stratonovitch P., Paul M.J.

Short periods of extreme weather, such as a spell of high temperature or drought during a sensitive stage of development, could result in substantial yield losses due to reduction of sink capacity resulting from decrease in grain number and grain size. In a modelling study (Stratonovitch & Semenov 2015), heat tolerance around flowering in wheat was identified as a key trait for increased yield potential in Europe under climate change. Ji et all (Ji et al. 2010) demonstrated cultivar specific responses of yield to drought stress around flowering in wheat. They hypothesised that carbohydrate supply to anthers may be the key in maintaining pollen fertility and grain number in wheat. It was shown in (Nuccio et al. 2015) that genetically modified varieties of maize that increase the concentration of sucrose in ear spikelets, performed better under non-drought and drought conditions in field experiments.

The objective of this modelling study was to assess potential benefits of tolerance to drought during reproductive development for wheat yield potential and yield stability across Europe. We used the Sirius wheat model to optimise wheat ideotypes for 2050 (HadGEM2, RCP8.5) climate scenarios at selected European sites. At those sites where water could be limited, ideotypes sensitive to drought produced substantially lower mean yields and higher yield variability compare with tolerant ideotypes. Therefore, tolerance to drought during reproductive development will be required for wheat cultivars optimised for the future climate in Europe in order to achieve high yield potential and high yield stability.

Topic: Addressing uncertainty and risk in climate change impact studies

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Probabilistic assessment of adaptation options from an ensemble of crop models: a case study in the Mediterranean.

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Uncertainty about future climate change impacts increases the complexity of assessing adaptations and risks at regional level. In modelling studies, uncertainty may arise from climate projections, field data and crop models. Approaches are required for effectively quantifying climate impacts and the effect of adaptations, managing inherent uncertainties and communicating the results. Here, we focus on assessing adaptation of wheat in a Mediterranean environment in 2030 and 2050 under the A1B scenario.

A probabilistic framework for evaluating the effect of feasible adaptation strategies for winter wheat in northern Spain was applied with an ensemble of 17 crop models. First, adaptations response surfaces (ARSs) were created. These are bi-dimensional surfaces in which the effect of an adaptation option (e.g. changes in crop yield compared to the standard management) is plotted against two explanatory variables (e.g. changes in temperature and precipitation). Then, the likelihood of the effect of adaptations was calculated using ARSs and probabilistic projections (PP) of climate change. The latter are joint probabilities of changes in the same explanatory variables used for drawing the ARSs. Therefore, ARSs were constructed and climate PP superimposed.

Based on ARSs, the most effective adaptations were mainly based on spring wheat, current and shorter cycle duration and early sowing date. Based on PP, these options increase yield with respect to no adaptations on average by 11% in 2030 and 15% in 2050. Also, the likelihood of maintaining current yields (i.e. standard management under current climate) is extremely likely (>95%). Other combinations of sowing dates and cycle duration were only promising when a single supplementary irrigation was applied.

Topic: Addressing uncertainty and risk in climate change impact studies
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Contribution of uncertainties from model structure, parameters and climate scenarios in climate change impact projections.

Fulu Tao, Reimund P. Rötter, Taru Palosuo, C. G. H. Díaz-Ambrona, M. Inés Mínguez, Mikhail A. Semenov, Kurt Christian Kersebaum, Claas Nendel, Davide Cammarano, Holger Hoffmann, Frank Ewert, Anaelle Dambreville, Pierre Martre, Lucía Rodríguez, Margarita Ruiz-Ramos, Thomas Gaiser, Jukka G. Höhn, Tapio Salo, Roberto Ferrise, Marco Bindi and Alan H. Schulman

Uncertainty in climate change impact projections originates mainly from the inadequacies in structure and parameters of the impact model, climate change scenarios and other input data. Previous studies tried to account for the uncertainty from one or two of the major sources. Here, we developed a super-ensemble-based probabilistic projection to account for the uncertainties from three major sources comprehensively. We demonstrated the approach by assessing projected climate change impact on barley growth and yield in the Boreal and Mediterranean climatic zones in Europe using eight crop models and multiple sets of crop model parameters under three representative climate change scenarios for the 2050s. We further quantified and compared the contribution of crop model structure, crop model parameter and climate change scenario to the mean squared error using the multivariate analysis of variance. The projected changes in barley yield due to climate change by the 2050s ranged from -45.8% to +26.3% at Jokioinen, Finland and from -54.8% to +78.6% at Lleida, Spain, relative to 1981-2010 level. Based on the super-ensemble probabilistic projection, the median of simulated yield change was -3.8% and +7.5%, and the probability of yield decrease was 0.57 and 0.43 in the 2050s, at Jokioinen and Lleida, respectively. The contribution of crop model structure, crop model parameters, and climate change scenarios to the mean squared error was, respectively, 37%, 53%, and 2% at Jokioinen, and 46%, 40%, and 2% at Lleida, for our setting with just three different climate scenarios. The super-ensemble-based probabilistic approach can provide more useful information and better understanding of the uncertainties in climate change impact projections.

Topic: Addressing uncertainty and risk in climate change impact studies
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When and why to predict using the mean or median of a crop multi-model ensemble.

Wallach, D., P. Martre, B. Liu, S. Asseng, F. Ewert, P. Thorburn, M. van Ittersum

The systematic use of crop multi-model ensembles (MMEs) has recently become widespread. In these studies, it has often been noted that ensemble predictors, in particular the mean (emean) or median (emedian) of the ensemble simulated values, are in close agreement with observations. If this is the case in general, using ensemble predictors could be an important pathway to improved model predictions and as a consequence to more widespread use of crop models. However, only a single study has specifically targeted the quality of ensemble predictors, and that was based on only limited data.

The purpose of this study was to analyze the behavior of the ensemble predictors over a much wider range of situations, and to propose a random effects statistical model of model error to explain and generalize the empirical findings. We analyze the results of applying MMEs to simulate five separate experiments, each designed to study the effects of a specific range of environmental conditions.

The basic finding, which confirms and extends previous studies, is that emedian and emean are the best or among the best predictors for every experiment and every response variable considered. Emedian in most cases is preferred to emean, but the differences are small. The empirical results also show that emedian and emean in general have high skill values. Finally, the results show that the skill values increase with the number of models in the ensemble.
The statistical model shows how these conclusions depend on overall bias of the models in the ensemble, and the variances of the random model effect, the treatment effect and their interaction.

Topic: Addressing uncertainty and risk in climate change impact studies
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Effect of changing size and composition of a crop model ensemble on impact and adaptation response surfaces.

Rodríguez, A., M. Ruiz-Ramos, T. Palosuo, R. Ferrise, I.J. Lorite, M. Bindi, T.R. Carter, S. Fronzek, N. Pirttioja, P. Baranowski, S. Buis, D. Cammarano, Y. Chen, B. Dumont, F. Ewert, T. Gaiser, P. Hlavinka, H. Hoffmann, J.G. Höhn, F. Jurecka, K.C. Kersebaum, J. Krzyszczak, M. Lana, A. Mechiche-Alami, J. Minet, M. Montesino, C. Nendel, J.R. Porter, F. Ruget, M. A. Semenov, Z. Steinmetz, P. Stratonovitch, I. Supit, F. Tao, M. Trnka, A. de Wit and R. P. Rötter

Climate change is expected to generate severe impacts in cropping systems and food production. Because of that, successful local adaptation is needed.

Impact response surfaces (IRSs) are tools that allow assessing responses of studied variables (yields) to systematic changes in two explanatory variables (e.g. precipitation, P, and temperature, T). Adaptation response surfaces (ARSs) show the impacts or efficiencies of adaptation measures within the same T and P change space. To quantify some important aspects of uncertainties of model simulations, the use of an ensemble of crop simulation models is recommended. Yet properties of climate model ensembles have been analyzed in depth, this is not the case for crop model ensembles.

Changes in ensemble composition and size can occur when the ensemble is extended to include new members, or when some are excluded (e.g. members giving implausible results). These changes can make an important difference on the results for both impact and/or adaptation simulations and affect the conclusions or management recommendations made based on them.

For this study we are utilizing simulations from an ensemble of crop models that were applied to simulate wheat growth in Lleida, northwest of Spain. The outputs of this ensemble have been used to create IRSs and ARSs, to analyze the response of wheat yield to a range of T and P perturbations, under different CO2 levels.

The objective of this study is to establish a methodology to show the effects of changing the ensemble composition and size on impact and adaptation assessment. The methodology developed here allows measuring the impact of the ensemble members' selection on the ensemble central tendency measures and on the IRSs and ARSs main features and allows for analysis of robustness of conclusions.

Topic: Addressing uncertainty and risk in climate change impact studies
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Using impact response surfaces to analyse the likelihood of impacts on crop yield under a changing climate.

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Most studies of future climate change impacts rely on estimates based on a limited set of projections of future climate. This way, it is not possible to determine whether one estimate is more or less likely than another. However, if future climate can be expressed probabilistically as a distribution across the range of climate uncertainty, this makes it possible to express impacts in terms of likelihoods, as demonstrated in this study.

The approach involves overlaying joint probability density functions (pdfs) that describe uncertainties in projections of temperature and precipitation change over future time periods with impact response surfaces (IRSs). The IRS shows the modelled sensitivity of crop yield across a wide range of systematic changes in the same climate variables relative to the baseline (1981-2010). The likelihood of falling short of a target yield threshold is then calculated by integrating across the area of the pdf where yields are below the threshold. This is the first application of the approach for present-day and adapted crop cultivars in Finland which also uses new RCP-based probabilistic projections of climate. The WOFOST crop model was run for a locally grown cultivar of spring barley in south-west Finland assuming contrasting clay loam and sandy soils. IRSs were constructed for seven future CO2 concentrations representing time periods during the 21st century, so that the time-evolution of impact likelihoods with respect to mean yield levels and inter-annual variability (reliability) can be presented. The effectiveness of adaptation options was demonstrated with simulations for cultivars with different development rates.

The approach is an efficient way to summarise results and communicate them to a wider audience. Results indicate that the CO2 fertilisation effect counteracts the decline in yields with higher temperatures, and that a future switch to later maturing cultivars would lower the likelihood of a shortfall and produce higher yields.

Topic: Addressing uncertainty and risk in climate change impact studies
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Sensitivity of a grassland model ensemble to climate change factors: the MACSUR approach.

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In grassland modelling, understanding feedbacks between grassland ecosystems and the atmosphere in the context of regional scale climatic changes is essential for the accurate quantification of ecosystem water and carbon (C) fluxes. Different grassland models respond differently to environmental conditions and climatic circumstances. To test the sensitivity of different models to changes in input variables, ensemble modelling approaches are used because they generate an expanded envelope of possible systemic outputs. Here, an ensemble modelling approach was applied to explore water and C fluxes from grasslands in Europe. Seven grassland models were run at nine long-term grassland sites representing a broad gradient of geographic and climatic conditions. The sensitivity to climate change factors including precipitation (P), temperature (T) and atmospheric CO2 concentration [CO2] was assessed. Baseline weather series (including [CO2]=380 ppm) were modified by changing T and P by -25%, -10%, -5%, +5%, +10%, +25% of the observed standard deviation and [CO2] by +5%, +10%, +15%, +25%, +50%, +100%. The obtained multi-model responses for each driver showed different levels of sensitivity. Soil temperature and gross primary production (GPP) displayed strong sensitivity to air temperature and precipitation. Based on the multi-model median of model responses, altered scenarios of precipitation had an important effect on modelled evapotranspiration from grassland swards. In general, yield biomass and GPP increased with elevated levels of [CO2]. Rising T and [CO2] had a fundamental effect on the C cycling of terrestrial ecosystems. This study demonstrates the use of ensemble modelling to address critical issues of uncertainty associated with individual model predictions, and provides increased understanding of water and C fluxes in grasslands under climate change.

Topic: Addressing uncertainty and risk in climate change impact studies
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What are the risks of food price changes? A time series analysis.

Hoveid, Øyvind

It is a widely held belief (IPCC) that climate change brings more risks to the world. With regard to food production, market prices might be expected to be more volatile. So far, the evidence of this is meager. With novel methods I show that the price volatility of wheat indeed has increased the last sixty five years. It cannot be proved, however, that the additional volatility is due to climate change. Alternatively, the cause might be market regime changes that arose with the oil embargo of 1973-74. Sixty five years of observations seems far too short to assess the long term relationship between climate and food price volatilities. Regardless of cause, commodity price changes has skewed distributions with higher probability for a certain price increase than for an equally sized decrease. This implies that the incentives for storage is stronger for users than for suppliers.

Topic: Climate change adaptation and mitigation at the farm scale
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Integrated assessment of farm level adaptation in Flevoland, the Netherlands: what did we learn from multiple methods and model chains?

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Climate change impact assessment requires farming systems analysis and integrated assessment. However, multiple models can be used to assess changes in drivers. In addition, farms are complex systems and many assumptions need to be made regarding objectives and constraints. Here, we evaluate the impact of different models and assumptions on impacts of climate change on arable agriculture in Flevoland, the Netherlands. We performed three studies. Firstly, we used the crop model WOFOST, market model CAPRI, and bio-economic farm model FSSIM. Secondly, we used the crop model SIMPLACE, an adapted version of CAPRI, and a different set up of FSSIM. Thirdly, we used the crop model WOFOST, estimates of impacts of extreme events by the Agro Climate Calender, and the bio-economic farm model FarmDesign. In general, climate change is projected to have positive impacts. The first two studies however showed that impacts of technology and price changes are larger. But while changes in gross margins are more influenced by results from crop and market models, changes in farm plans are more influenced by assumptions regarding resources and constraints. Assumptions regarding the available land for rent largely influence results. The third study showed that when policy constraints are neglected, impacts on gross margin are more positive. Positive impacts of average climate change may however be counterbalanced by negative impacts of extreme events, but adaptation measures are available. When considering soil quality as important objective, adaptation at farm level will be different: instead of more potato or sugar beet, farms will grow more wheat. We conclude that climate change impacts depend on assumptions, but when making this transparent, it can inform adaptation.

Topic: Climate change adaptation and mitigation at the farm scale
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Influence of environmental climate conditions on animal welfare criteria of lactating dairy cows.

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Objective
Naturally ventilated barns (NVB) are affected by climate-related changes. The influence of environmental climate on animal welfare of lactating dairy cows was investigated.
Material and Methods
This study was carried out at a NVB in Germany (Holstein Friesian cows; 1st to 8th lactation; daily milk yield 38.2 ± 9.4 kg). The relative humidity (RH,%) and ambient temperature (T,°C) were measured in 5-min intervals with 8 EasyLog USB 2+ sensors (Lascar Electronics Inc., USA) and in 10-min intervals with 2 LogTags (HAXO-8, LogTag Recorders, New Zealand). The Temperature Humidity Index (THI) was calculated according to NRC (1971)i. Respiration rate (RR, visually counted hourly in 30 sec.), rumination activity (RA, recording with microphone in 2h-periods) and activity behavior (AB, IceTag3DTM-Pedometer at hind leg recording body posture every sec.) are used to characterize heat stress.
Results
RR: Cow-related factors (body posture, milk yield performances) and THI influenced the RR of lactating dairy cows. The values of RR in lying cows were greater than in standing cows. An increase of RR was observed per additional produced kg milk per day.
RA: RA followed feeding times, but it was affected by environmental climate conditions, too. Cows spent more time on rumination during the late evening and the night, when THI was the lowest. The rumination time decreased strongest with increasing THI from 1600 to 2000h.
AB: The duration of lying per day decreased by increasing ambient temperature and the duration of standing rose, but the duration of moving remained constant. The strongest changes in behavior could be recorded during the afternoon.
Conclusion
Heat stress in dairy cattle is a multifactorial process. The climate conditions strongly influence the respiration rate and behavior (activity and rumination) in dairy cows. These factors influence each other.

References: NRC (National Research Council, 1971), A guide to environmental research on animals, National Academy of Science, Washington DC

Topic: Climate change adaptation and mitigation at the farm scale
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Drivers and trends for agricultural soil management – a foresight study for Germany.

Anja Techen & Katharina Helming

Climate change is a strong driving force for agricultural soil management. However, adaptation pathways of agricultural management to climate change also depend on other, interacting driving forces. These include socio-economic drivers (consumer demand, factor costs, policies, farm(er)s' attributes), bio-physical drivers (land availability, soil degradation, resource scarcities) technological drivers (ICT & robotics, tillage, biomass utilization, research & monitoring). A decent understanding of such driving forces and how they might be translated into trends of soil management is necessary to inform scenario development and modelling for analyzing climate change adaptation in terms of yields, economic performance and environmental integration. We conducted a foresight review of driving forces and trends for soil management in Germany as an example. We distinguished between quantitative trends (namely intensification vs extensification) and qualitative trends in soil management. While quantitative trends have been addressed in modelling studies since long, qualitative trends imply a higher degree of uncertainty in terms of their characteristics and implications. We differentiate such qualitative trends into five categories: (i) Crops and rotations, (ii) mechanical pressures, (iii) inputs into the soil, (iv) spatial patterns of cropping systems, (v) general behavior concerning soil management. We outline possible developments of such management categories including preliminary uncertainty estimation and consequences for the integration of productivity performance with environmental concerns.

Topic: Climate change adaptation and mitigation at the farm scale
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Cost-effectiveness of greenhouse gases mitigation measures in the Andean agriculture: an economic and environmental perspective

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The study was carried out in the Andean region of Ecuador, because this is the largest agricultural region of the country and may illustrate the Andean farming systems of all South America. We focused on potato crop because it is one of the main sources of employment and income in regional rural sector and because it is a staple food in the diet.

We estimated the mitigation potential of measures and their associated costs, assessing environmental and economic approach. Our methodological approach is summarized below:

(1) We made a list initial of GHG mitigation practices in agricultural soils based on literature review and contributions from the research team. Practices not applicable to crop were eliminated.

(2) The abatement potential of practices was evaluated by information taken from publications and studies in regions with climatic conditions similar to the area study.

(3) We estimated the marginal abatement cost (US$·tCO2e-1) by calculating the abatement potential rate (tCO2e·ha-1·yr-1) and the change in profits of farmers when using mitigation practices (US$·farm-1·yr-1).

(4) We selected practices more cost-effective through marginal abatement cost curves (MACC)
In the last decade there has been a development of policies and programs in Ecuador aiming to increase household food security, to reduce poverty through improved livelihoods. However, a significant number of voluntary national mitigation actions are being developed. These results were used to contribute to the knowledge of mitigation options at a regional level and to provide information about climate change and agricultural policies in the Andean region. Finally, the study provides a methodological framework that can be easily applied to other crops.

Topic: Climate change adaptation and mitigation at the farm scale
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Integrating the impact of climate change, price changes and recent CAP orientation on Mediterranean farming systems.

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It is of interest to compare the possible impact of climate change (CC) on agriculture with the possible effects of changes in the agricultural policies and regulations, as well as market conditions. In this regard, recent studies show that the impact of changes in the policies, regulations and market conditions may be even larger than that of the CC and may determine the changes in land use and livelihood strategies of farms in highly vulnerable areas to CC. New technologies could compensate for the adverse impacts of increased occurrence of negative conditions. On the other hand, changes in the ratios between commodity and factor prices interact with CC, in some cases balancing its impacts, in other cases accentuating them. In addition, new market regulation such as the abolishment of the milk quota and many measures originating from the recent orientation of the CAP may contribute to improved adaptation to the CC.
In this paper we review the analysis of the impact of CC in the Oristano MACSUR study area, to integrate the influence of elements, other than CC, on the management and adaptation strategies of local farming systems. We focus on milk quota abolition, CAP reform, with new direct payments, new price conditions and technological improvements as provided by the CAPRI network. The study represents the productive conditions of the area with a discrete stochastic programming model specified for its main farms types, irrigated and rainfed. This version of the Oristano model allows adjustment of herd and flock characteristics, acreage of tree crops and other structural elements. The assessment verifies the relationship between impact of CC and the influence of policy, and of new technological and market conditions.

Topic: Climate change adaptation and mitigation at the farm scale
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Impacts of climate change on Scottish beef farms – integrating crop production and economy in a meta-model.

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This paper explores the impacts of climate change on Scottish beef farms and identify possible adaptation measures available to the farmers that optimises farm outputs under changed climate. It uses an integrated platform of a bio-physical model (SPACSYS) and an economic farm level model (ScotFarm). The SPACSYS model projected physical changes in bio mass of the major crops and grass in Scotland under four scenarios; a baseline scenario (with current climatic conditions) and 3 climate change scenarios (two extremes and one mid-way climate projections under A1B SRES emission scenario). The outputs of this model, specifically, the projected crop and grass yields as well as field time availability (for grazing and machinery use on farm) under all 4 scenarios were fed into ScotFarm to determine financial implication of those changes under each of the climate scenario. This economic model used farm level data taken from Farm Accountancy Survey, 2015 which consisted of 105 specialist beef farms across the country. The model results under the climate change scenarios were compared with the results under the baseline scenario to determine the projected physical, financial impacts of climate change scenario on beef farms. The model also examined the responses of beef farmers which were considered as optimal farm adaptations to maximise farm profits under climate change scenarios.

Topic: Climate change adaptation and mitigation at the farm scale
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Assessment of climate change impacts on SOC dynamic in rainfed cereal cropping systems managed with contrasting tillage practices using a multi model approach.

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Conservation tillage (i.e., reduced - RT and no till - NT) is frequently proposed as mitigation practices as it can contribute to increase soil organic carbon (SOC) compared to conventional mouldboard ploughing (CT). In this study, we assessed the long-term effects of different tillage management practices on crop yield and SOC stock dynamics in Mediterranean rainfed cereal cropping systems at current and future climate scenarios. We relied on data obtained from long term experiments (LTEs) coming from ICFAR network coupled with four simulation models (APSIM, DSSAT, EPIC, SALUS). Two LTEs dataset were used: AN (Ancona, Marche, 1994-2015) characterized by a two-year durum wheat-maize rotation (NT vs CT: 40 cm deep mouldboard ploughing) and PI2 (Pisa, Toscana) based on a maize continuous crop from 1994 to 1998 followed by a durum wheat-maize rotation (RT: 15 cm disc tillage; vs CT: 30 cm deep ploughing). Climate scenarios were generated by setting up a statistical model using predictors from ERA40 reanalysis and seasonal indices of temperature and precipitation from E-OBS gridded data for the period 1958-2010. The statistical downscaling model was applied to CMCC-CM predictors to obtain climate scenarios at local scale over the period 1971-2000 and 2021-2050 (RCP4.5 and RCP8.5 emission scenarios). The multi-model mean was able to better reproduce with less associated uncertainty the SOC dynamics than a single model, hence better SOC predictions are also expected to occur in the future assessment. Overall, our study showed a decrease of SOC stocks in both sites and tillage systems in future scenarios. However, even if conservation tillage was more affected by climate change losing more SOC than CT, these systems were still able to stock more soil organic carbon also under future scenarios.

Topic: Climate change adaptation and mitigation at the farm scale
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Multi-criteria tools for the assessment and implementation of geographically targeted measures to mitigate nutrient losses and adapt to climate change - examples from Denmark.

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Like most livestock dense agricultural areas in North-Western Europe, the Danish macsur.eu study site around Norsminde Fjord, and Danish livestock agriculture in general, have significant problems with nutrient losses and greenhouse gas emissions. Consequently, challenging policy targets have been set for the reduction of nitrogen and phosphorus losses as defined in the EU Nitrates and Water Framework Directives, and in action plans for related reductions in greenhouse gasses. Climate change, with expected more winter rain and higher temperatures, potentially makes this problem worse, and mitigation options are urgently needed.

The present paper presents a suite of tools for the assessment of mitigation measure implementation to deal with this nutrient loss, greenhouse gas emission and climate adaption problems. In common for the studies presented are the integration of geographically targeted measures at the landscape level and experiences with stakeholder interactions. This also include multi-criteria assessment of the various effects of measures. Especially, the case of buffer strips as a geographically targeted measure is discussed, based on findings from the www.Buffertech.dk research project, and as one of the measures in the www.dNmark.org research alliance, landscape level impact assessment model presented. Finally, these results are discussed in the context of the www.macsur.eu joint programming research in livestock systems (LIVE-M) and in relation to the specific MACSUR case studies in Denmark and other European countries.

Topic: Climate change adaptation and mitigation at the farm scale
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Targeting and prioritization of interventions for reducing enteric methane emissions: findings and lessons from 13 countries.

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Globally, ruminants (dairy and beef cattle, goats, and sheep) constitute the largest source of anthropogenic emissions of methane (CH4) and, based on the activity of CH4 in the atmosphere, livestock CH4 emissions have been responsible for close to 20% of the warming the earth has experienced since the beginning of the industrial revolution. Ruminant livestock produce about 2.7 Gt CO2 eq. of CH4 annually, of which FAO estimate that about 500 Mt CO2-eq. can be mitigated through widespread adoption of known good practices that increase productivity. A range of technological options for interventions exists that have varying environmental and economic impacts and costs. Identifying appropriate interventions requires understanding the trade-offs across levels from farmers to sub-national and national policy makers and consideration about what is appropriate for given contexts. Targeting and prioritizing approaches narrows an extensive list of possible practices down to a range of best-bet options that can be scaled out. This paper will present the approach applied to assess and prioritize interventions for reducing enteric CH4 in 13 countries (Argentina, Uruguay, Sri Lanka, Bangladesh, Ethiopia, Kenya, Uganda, Tanzania, Senegal, Benin, Niger, Mali and Burkina Faso). More specifically, it will present (i) detailed baseline estimates of enteric CH4 emissions from ruminant systems estimated using the Global Livestock and Environment Assessment Model (GLEAM) and comprehensive locally-obtained data; (ii) potential mitigation packages developed by local experts and assessed for both their ability to reduce GHG emissions and their cost effectiveness; (iii) results from prioritization of mitigation interventions based on their impacts on enteric CH4, productivity and profitability.

Topic: Climate change adaptation and mitigation at the farm scale
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Tools to support farmer decision – making in arable cropping systems.

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Climate change is requiring the farmers re-evaluate their farming system. There is a need for the arable sector to reduce their emissions of greenhouse gases, and to adapt their systems to the changing climate. To assist farmers in the decision making process, tools have developed that will assists farmers in understanding the cause of these emissions and therefore assist in identifying the potential for mitigation. Tools have also been developed with the purpose of understanding the role of crop choice on nutrient supply and organic matter status. Efficient use of nutrients and maintaining or enhancing the soil carbon stocks will have benefits in terms of mitigation and for the long-term sustainability of the farming system. The farmer friendly tools that have been assessed for their ability to aid decision-making under climate change are namely 1) AgRECalc©, a farm-level carbon-footprinting tool, 2) Soil Explorer, a field-level tool for assessing carbon and nitrogen losses from fertilisation, and 3) ROTOR, a crop rotation planning and evaluation tool.

The tools need to be easy for the farmer to use and therefore the input data needs to be relatively easily obtainable, and the output needs to be in an accessible format. ROTOR is used to evaluate alternative cropping strategies and the implications of these strategies for nitrogen and soil organic carbon balance, Soil Explorer assesses the effects of these rotations on the soil carbon balance and the losses of nitrogen from the system, and AgRECalc is used to determine the effects of these changes on the emissions from the farming system. Thus in terms of mitigations, the tools can identify the effect of changes in management that affect the cropping system's impact on emissions, changes in soil carbon and nutrient cycling. The tools have been used to assess the effect of current management of the key attributes assessed by the models for the three organics arable sites, which are situated in Scotland, The Netherlands and Germany.

Topic: Climate change adaptation and mitigation at the farm scale
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Opportunities for soil carbon sequestration under old and new grazed grassland in the Netherlands.

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Soil carbon sequestration under agricultural soils is mentioned by the IPCC as a mitigation method to withdraw carbon-dioxide from the climate system of the earth. Grasslands could contribute to the withdrawal. In the Netherlands some grasslands are historically an important source of fodder for ruminants. Besides these relatively old soils the Netherlands has also relatively new soils, that are reclaimed from the sea. In a phosphorus (P) field trial that started in 1997, two old sandy soils, with an estimated agricultural use of 800 years, and a young clay soil, reclaimed in the 50s and in use from the 70s of last century, were part of the trial. In the trial the grassland use was a mixed grazed and mown system, as is usual on grazed farms in the Netherlands. Organic manure was annually applied, at a legally allowed dosage of balanced P fertilisation. On the two sandy soils the trial was running for 16 and 17 years, and on the young marine clay for 20 years and is still running. Soil organic carbon (SOC) was measured in this field trial, in 0-5, 5-10, 10-20, and 20-30 cm below surface.

On the old sandy soils the SOC did not change over the trial period. On one sandy site, where the botanical composition was changed to a more clover-based sward, the division over the layers changed slightly: the SOC in the top soil decreased and increased in the two lower layers. On the other sandy site the SOC did not change. In the young marine clay, however, the SOC increased in all layers except on a field were no organic manure was applied and was not grazed.

Assumed is that the old grasslands were saturated with SOC and that the clay soil could still sequester more carbon. The saturation level of this site is not known yet.

Topic: Climate change adaptation and mitigation at the farm scale
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The feed story for dairy production systems under climate change.

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Of all ruminant production systems, high-yielding dairy cows have the most stringent criteria on nutrition, with feed intakes up to more than three times that required for maintenance alone. For this reason, dairy production systems provide an interesting case study with which to explore the implications of climate change on feed provision and utilization by the animal. Dairy production systems across Europe vary widely in production intensity and in nutrition strategies applied. Systems range from almost fully grazed to almost fully confined systems, and from low to high production intensities (per cow or per farmed hectare) of: external resource use (e.g. feed purchased), level of farm automation and technology application, and financial investment. Irrespective of this huge variety of dairy farming systems, they have in common that home-grown roughages are an important part of the diet. Climate change will directly impact on roughage production and hence on: the supply and quality of roughages, the nutritional strategies adopted and cow performance. Indirectly, through its impact on home-grown roughages climate change will also impact on the requirements for: home-grown feed crops, purchased feed crops, supplemental by-product feeds (for example, from the food or bio-energy industries) and processed concentrate feeds, depending on whether production targets are to be maintained or not. These potential consequences of climate change have been reviewed. Challenges addressed and presented here will include the need to reduce phosphorus and nitrogen surpluses and/or losses from the system. The implications and limits to various nutritional adaptation strategies, and the alternatives available to farmers and the feed industry, will be discussed in the context of recent scientific insights and against the background of the models and modelling concepts currently in use in practice and in research.

Topic: Climate change adaptation and mitigation at the farm scale
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Rethinking farm-scale modelling to meet new challenges and possibilities.

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Historically, agricultural models have tended to be created, owned and maintained by a single person or research organisation. This modus operandi is often proving fragile, when confronted with budget constraints and staff turnover. Collaborative modelling is proving to be a viable alternative that has numerous advantages; it allows costs to be shared, buffers budget and staff changes in individual organisations, increases quality control of model code and extends the biophysical and management dimensions of model testing. However, collaborative modelling itself presents practical and cultural challenges that must be overcome and also imposes some costs. We here reflect on the experience garnered through the development of two modelling platforms: APSIM and RECORD.

Topic: Projecting climate change impacts on agriculture in European regions
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Spatially explicit estimation of climate change related heat stress on the milk production of dairy cows in the United Kingdom.

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The impact of climate change on dairy cows' milk production in the UK has been investigated using a gridded modelling approach. 12 milk loss calculation methods based on the Temperature Humidity Index (THI), which accounts for the impact of heat stress, and eleven climate projections (UKCP09) with 25 km spatial resolution and covering the 1950-2100 period were used in the study. Half of the investigated methods used daily meteorological data. The other methods used finer temporal resolution input data. The number of days when dairy cows are projected to be affected by heat stress will increase sharply as we approach the end of the century: e.g. In Southern-England, the number of days of heat stress increases from an annual average of 10 (baseline: 1990s) to over 40 per year. The associated milk loss will rise from a 30 kg/cow/yr up to 200 kg/cow/yr. In extreme years in the South the annual milk loss may exceed 1000 kg/cow. By the end of the century, dairy cattle in large portions of Scotland and Northern Ireland will experience the same level of heat stress as cattle in Southern-England today. The number of days when daily step methods result in no milk loss while sub-daily time step methods result in non-zero milk loss increases throughout the century. Consequently, simple methods that use only daily average temperature and relative humidity values may underestimate the impact of heat stress in the future.

Topic: Projecting climate change impacts on agriculture in European regions
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A pan-European analysis of the spatio-temporal patterns of yield gap and abiotic stresses for wheat.

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Environment characterization and yield gap analysis are important for plant breeding to understand genotype by environment interactions and to optimize field trial networks. This understanding is a key aspect to reach the needed improvements in crop yield to achieve food security and for agricultural and environment policy evaluations. However, a characterization of abiotic stress scenarios of their recent changes at the European level for rainfed wheat are still missing. Here, wheat responses to various combinations of environmental stresses (that is, water, nitrogen and temperature limitations) were simulated at a spatial resolution of 25 × 25 km for the period 1985-2014. Results showed that at the European level, environmental stresses have resulted in an average production loss of 111.4 million tons per annum, of which 59% was contributed to by drought. Over the studied period, simulated environmental yield gap decreased at a rate of 0.22% per annum, in particular water-limited yield gap has decreased at lower latitudes but it has increased in continental regions. Five environment types were identified based on daily patterns of total above ground biomass loss due to water deficit. The spatio-temporal patterns of the identified environment types show that the occurrence probability of environments without drought or with mild water shortage has been increasing at the European level while that of mild water stress from the vegetative stage onwards and severe water shortage between anthesis and maturity has been decreasing. Among the nine largest wheat producing European countries, these changes were particularly significant in Italy, Romania and Spain.

Topic: Projecting climate change impacts on agriculture in European regions
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Assessing the role of farm-level adaptation in limiting the local economic impacts of more frequent extreme weather events in Dutch arable farming systems.

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The expected increase in extreme events frequency is likely to considerably affect future crop productivity. Appropriate adaptation measures in agricultural systems should be identified according to the main climate risks expected in a region and taking into account the role of decisions made at the farm level. Yet, there is limited understanding of the interplay between local production capabilities, regional climatic changes and more general socio-economic conditions. We propose a method that combines local productivity factors, economic factors, crop-specific sensitivity to climatic extremes, and climate change scenarios, to assess future economic impacts of extreme events on agricultural systems. Our assessment is spatially explicit and uses discounted time series of cash flows taking into account expected impacts on yield and crop quality, to estimate changes in the expected net present value of agricultural systems. We also assess the economic feasibility of a portfolio of adaptation measures by considering their initial investments, annual costs, and effectiveness in reducing crop damage. We apply the method to investigate potential economic impacts of extreme events in arable farming systems in the Netherlands in period around 2050. We find that the expected increase in frequency can substantially undermine the economic viability of Dutch arable farming systems. The results indicate considerable differences among regions: some regions are severely impacted by all extremes, while others consistently demonstrate high resilience. Though the exact magnitude of the impacts remains highly uncertain, adaptation measures should nevertheless be regarded as no-regret strategies, since they alleviate both economic impacts and uncertainty around impact magnitude.

Topic: Projecting climate change impacts on agriculture in European regions
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A scenario-neutral approach to understanding the regional land use change and food supply consequences of future climate and socio economic change.

Sandars, D. L., E. Audsley, I. P, Holman

Europe's ability to feed its population depends on the balance of agricultural productivity (future climate, yields and land suitability) and demand (socio-economic and technology change such as population, food choice, imports, & environmental choices). Given the widely recognised future uncertainty in both of these, this presentation uses the IMPRESSIONS Integrated Assessment Platform (IAP), The IAP contains meta-models of optimal cropping and crop and forest yields derived from the outputs of the previously developed complex models (Audsley et al; 2015).The profitability of each land use is modelled for every soil in every 10 minute grid across Europe. Land use in a grid is then allocated based on profit thresholds. The model iterates the price of six commodity groups until demand is satisfied or cannot be met. The model has been systematically run with perturbations against the baseline of five key variables: annual temperature, annual precipitation, atmospheric carbon dioxide levels, European population, and finally, plant yield changes due to restrictions or genetic and technological developments. The land use results for each scenario are aggregated into 8 climatically-distinct regions. Contour plots are used to display impact response surfaces that demonstrate differing regional sensitivities and tipping points, affording insights into the regional opportunities and threats that the future may offer to European agriculture and forestry.

Audsley E, Trnka M, Sabate S, Maspons J, Sanchez A, Sandars D, Balek J, Pearn K (2015) Interactively modelling land profitability to estimate European agricultural and forest land use under future scenarios of climate, socio-economics and adaptation. Climatic Change 128:215–227 DOI 10.1007/s10584-014-1164-6

Topic: Projecting climate change impacts on agriculture in European regions
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Future climate change, yield variation, and impacts on farm management: a case study at a pilot regions in Finland.

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Crop production in northern regions such as in Finland is projected to benefit from longer growing seasons brought by future climate change. However, production is also facing multiple challenges under more frequent and extreme weather. More frequent drought stress, heat stress and other environment-related constraints may lead to higher yield variability in different regions and increase the yield risks faced by farmers. Changes in yield potential and relative profitability between crops caused by climate change is likely to be different in different regions. The purpose of this paper is to develop a method to evaluate the impacts of adaptation and mitigation options on farms with different socio-economic characteristics. Both socio-economic and biophysical factors affect rational decision-making process at a farm level and production decisions. Based on the results from carefully chosen climate models under three SRES scenarios, together with different market price scenarios, we attempt to identify how future changes in mean yields and yield variation caused by climate change in two regions in Finland may affect local farm land allocation and farming management practice. We study how management choices such as crop choice, crop rotation, fertilization, crop protection and liming are affected and if these changes are in synergy or in conflict with mitigation. This study contributes to the development of integrated modelling methods needed to assess impacts of global changes on farming systems.

Topic: Projecting risks and opportunities for farming and food production in regional case studies
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Impacts of Climate Change Adaptation Options in Agriculture on Soil Functions: Examples from European Case Studies.

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Soil functions are fundamental for food security and for provision of ecosystem services for sustainable development. Climate change affects soil functions directly through changes in temperature, rainfall and moisture regimes, and indirectly via adapted management practices. While comprehensive evidence exists for the direct effects such as increased soil erosion risks, accelerated nutrient turnover and gas fluxes, less is known about how agricultural adaptation pathways may affect soil functions. The objective of this study was to analyze the evidence from European case studies about the possible impacts of climate change adaptations on soil threats and soil functions, and link soil functions to the Sustainable Development Goals (SDGs). We analyzed 20 regional case studies across Europe using Driver-Pressure-State-Impact-Response (DPSIR) framework. Our major findings were (1) adaptation pathways reflected local conditions, (2) reduced soil erosion threats and decelerated organic matter decline were anticipated in more than half of the cases, but soil compaction risks may increase in some areas, (3) the majority of adaptation pathways were expected to improve three soil functions, namely food and biomass production, carbon sequestration, and storing, filtering, transforming and recycling capacities, with little evidence about possible implications for soil biodiversity, (4) the contribution of soil functions to SDGs suggests improvements regarding SDG 2 (food security and sustainable agriculture) and SDG 13 (climate action), whereas SDG 15 (terrestrial ecosystems) requires attention. In conclusion: while direct climate change effects are expected to increase soil degradation, agricultural adaptation may counteract this process in many regions in Europe.

Topic: Projecting risks and opportunities for farming and food production in regional case studies
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How does the projected climate change impact on dry matter yields, greenhouse gas emissions and economics in Norwegian dairy farming systems?

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Future climate projections showing increases in the air temperature and the number of rainy days in Norway will require changes in feed-base to adapt to climate change. A large number of studies have used single models to quantify the effects of management-related changes on productivity, greenhouse gas (GHG) emissions and profitability. Here, we combined four models: BASGRA and CSM-CERES-Wheat, HolosNor and JORDMOD to estimate the impacts of projected climate conditions on grass and wheat dry matter (DM) yields, farm level GHG emissions and profits. Simulations were carried out for baseline (1961-1990) and future (2046-2065) climate conditions projected based on two climate models and for production conditions with and without a milk quota. We compared four locations with different climate conditions for low, and median and high yielding years. The spring wheat grain DM yields simulated for the same weather conditions within each climate projection varied between 2200 kg and 6800 kg DM per ha. The GHG emissions intensities (kilogram carbon dioxide equivalent: kgCO2e emissions per kg fat and protein corrected milk: FPCM) varied between 0.82 kg and 1.25 kg CO2e per kg FPCM, with the lowest and highest emissions found in central Norway and south-east Norway, respectively. The farm profitability expressed by total national land rents varied from 1900 million Norwegian krone (NOK) for median yields under baseline climate conditions up to 3900 million NOK for median yields under future projected climate conditions. The projected future change in climate evaluated here decelerated the production of GHG emissions from dairy production in the locations assessed due to higher milk yields per cow and partly to higher crop yields.

Topic: Projecting risks and opportunities for farming and food production in regional case studies
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Yield gaps of cereals across Europe.

Schils, RLM and Van Ittersum, M

To find proper compromises between land productivity, resource use efficiency and environmental impact, benchmarking of yields is a helpful starting point. Yield gaps are defined as the difference between potential or water-limited yield and actual yield. The GYGA project applies a consistent bottom-up approach to estimate yield gaps per country. Here we focus on the application for wheat, barley and maize in Europe. For each country, a climate zonation is overlaid with a crop area map. Within climate zones with important crop areas, weather stations are selected with at least 10 years of daily data. For the dominant soil types within a 100 km zone around the weather stations, the potential and water-limited yields are simulated with the WOFOST crop model, using location-specific knowledge on crop systems. Data from variety trials or other experiments, potential or water-limited yields, are used for validation and calibration of the model. Actual yields are taken from sub-national statistics. Yields and yield gaps are scaled up to climate zones and subsequently to countries. The average national simulated potential wheat yields under rainfed conditions varied from around 5 to 6 t/ha/year in the Mediterranean to nearly 12 t/ha/year on the British Isles and in the Low Countries. The average actual wheat yield varied from around 2 to 3 t/ha/year in the Mediterranean and some countries in East Europe to nearly 9 t/ha/year on the British Isles and in the Low Countries. The average relative yield gaps varied from around 10% to 30% in many countries in northwest Europe to around 50% to 70% in some countries in the Mediterranean and eastern Europe. For an initial understanding of yields and yield gaps, we assess differences between climate zones, soils and in relation to nitrogen input.

Topic: Projecting risks and opportunities for farming and food production in regional case studies
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How to achieve higher yield levels in North Savo – means and challenges indicated by farmers.

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Sustainable intensification of Nordic farming systems is seen as an effective adaptation and mitigation strategy. Two stakeholder workshops targeting sustainable farming under changing climate were arranged in North Savo, Finland in 2014 and 2016 with farmers and other regional agricultural stakeholder participants. Workshop outcomes are presented and discussed.

The most important changes in the operational environment of farms in North Savo during past decades, identified by the participants, were related to agricultural policies and subsidy systems. They were seen strongly supporting extensification and undermining motivation for yield improvements. Long-term trends in weather patterns were not taken up by farmers. The most important obstacles for higher yields mentioned were soil fertility, particularly in relation to soil compaction and insufficient drainage, but also low motivation for improvements and lack of know-how.

Workshop participants identified improving soil fertility with drainage and liming, improved crop rotations, better sowing techniques including overseeding, careful selection of cultivars and forage grass mixtures as important means for higher crop yields. Suggested solutions for improving both crop yields and farm economy were to 1) increase collaboration among farmers, 2) focus only on the most productive fields and 3) actively develop farming skills.

The workshops provided important perspectives on future farming development, as well as needed developments of model-based integrated assessments which must reliably reflect the impacts of different management actions on yields, environment and farm economy. The challenge is also to correctly describe the impacts of increasing collaboration and cost sharing among farmers.

Topic: Projecting risks and opportunities for farming and food production in regional case studies
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Modelling nitrous oxide emissions of high input maize crop systems.

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Arable soils are a large source of nitrous oxide (N2O) emission and several factors may affect the processes responsible for its production (nitrification and denitrification). In particular, forage crop systems for dairy farming are among the cropping systems with highest N input, mainly because they are based on high yielding forage grasses such as maize. A number of options have been explored to decrease the emissions but they remain site specific and are related to climatic, soil and local availability of management options. Moreover, guidelines for estimating N2O emission from agricultural soils does not take into account different crops, soils, climate and management, all of which are known to affect nitrification-denitrification and N2O production and emission.

Process-based models represent a promising route to capture the spatial and temporal variability of N2O emissions, along with the effects of crop management. Nevertheless, the testing and comparison of these models have been limited to only a few works, with studies mainly based on biogeochemical models rather than process-based crop models. Furthermore, a multi-model ensemble analysis, which proved to be the best option for crop system analysis, has not been done extensively for the simulation of N2O emissions to addressing the various options for mitigations practices related to maize crop fertilization systems.

Our objective is to evaluate the performance of several process-based models in simulating N2O emission under different type, amount, rate of N fertilizer, i) quantify N2O emission, as a function of nitrogen inputs, across a wide range of soil types and environmental contexts; ii) assess the uncertainty in simulating N2O emission, and iii) identify efficient mitigation of N-fertilized maize systems.

Topic: Projecting risks and opportunities for farming and food production in regional case studies
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Developing a framework for critical assessment of stakeholder engagement activities.

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Multi-actor approaches to research are essential to meeting the complex challenges facing the agricultural sector in Europe. From a practical perspective, working with stakeholders can enhance the relevance of research findings, and increase the chances of achieving changes in practice. Recent work within the Modelling European Agriculture with Climate Change for Food Security (MACSUR) project analysed seven case studies of stakeholder engagement involving partners from the consortium. This initial study revealed a number of categories underlying the individual cases. These categories highlighted the interactions between the actors involved (including scientists) and how these were shaped by, and shaped, external and internal structures and processes. Here, the categories which emerged from the initial study have been developed into a simple approach for the critical assessment of engagement activities. A qualitative framework is being developed, composed of five elements derived from the initial study: external shaping, shaping by priority, shaping by role, shaping by actions and pathway to impact. Development of qualitative indicators to support the assessment of each element relative to theoretical best practice is ongoing. Applications of the nascent framework, including assessments of MACSUR regional case studies, are presented to illustrate its potential. Use of the framework in engagement design and review is intended to minimise unintended consequences arising from unrecognised issues relating, for example, to the effects of power inequalities between the social worlds of different stakeholder groups. It provides a structure for systematic reflection on such elements, either when designing a stakeholder engagement activity, as a reflexive exercise during implementation, or in order to assess a completed activity. Complementing current practical frameworks for good practice in stakeholder engagement, this tool is being designed to address critical aspects of engagement in the context of quantitative research, including the development and use of models as part of integrated assessments.

Topic: Projecting risks and opportunities for farming and food production in regional case studies
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Creating a dynamical farmer population model at country scale level.

Beckers, V., Beckers, J., Vanmaercke, M., Van Rompaey, A., Dendoncker, N.

Western Europe has a long agrarian history; shaping the landscape and the environment for centuries. In Belgium, high population density together with lack of spatial planning during the first half of the 20th century led to urbanization of the countryside. Due to limited availability of land and other socio-economic reasons, farmers were forced to either specialize and intensify, or quit. Total farmed area in contrast, only decreased slightly since 1980, resulting in increased average farm size. This is a trend that can be observed throughout Western Europe.
The remaining farmers stay under pressure requiring constant adaptation and investment, resulting in continued agricultural land use changes.
Understanding of these significant trends and their impact on the land use and environment requires a deeper understanding of the mechanisms behind the decreasing number of farms and the impacts of different policy measures.
Therefore, a farmer model (FarmMo) was created in order to gain insights into these trends and explore the effect of certain policy measures. The model works at parcel scale and outputs the number of farms, the size of the farms and the crops on the fields in order to create a plausible farmer population with a plausible size and spatial distribution of the farms.
After calibration, first results were obtained for a sub-region in Belgium.
Further tests will prove whether the model continues to be reliable on the country scale level and will give more information on the reliability of the crop related decisions.
The model will then enable the test the impact of different agriculture subsidizing strategies (e.g. based on farm size, production, crop types) on farms and the farmer population.
The presentation will describe the model, the results and the potential ways for policy makers to use the model in their decision-making process.

Topic: Novel impacts from climate change, new approaches for adaptation and mitigation
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Integrated modelling of agricultural adaptation and the value of precipitation information in a semi-arid Austrian region.

Karner, K., Mitter, H., Schönhart, M., Schmid, E.

Precipitation patterns of future climate change are still uncertain and impose large risks for agricultural production particularly in semi-arid regions. Efficient adaptation is required in order to appropriately deal with associated risks and utilize potential opportunities. We aim at i) analysing the impacts of three future precipitation scenarios on agricultural production in a semi-arid region in Austria, ii) assessing efficient agricultural adaptation measures, and iii) computing the value of precipitation information (VOI). We employ an integrated assessment framework consisting of a regional climate model, a crop rotation model, a bio-physical process model, and a bottom-up land use optimisation model with a groundwater balance equation to limit available irrigation water. The model results show that changes in land use and management are substantial in the different precipitation scenarios. Especially the area of vineyards is sensitive to available irrigation water. If precipitation remains constant or increases, vineyards would expand by 93% or 125%, respectively. A precipitation decline would also result in increased land abandonment, reduced crop and wine production and hence lower regional net-benefits (11.5 million € compared to 38 million € if precipitation increases or 27 million € if it remains constant). Modelled management changes arise amongst others in the form of irrigation changes. Irrigation decreases (- 74%) in a drier scenario and increases in a wetter scenario (+47%) compared to the past. The value of precipitation information amounts to 4.7 million € in the dry and 4 million € in the wet scenario. This study shows that accurate precipitation information is important for identifying climate change impacts and thus efficient agricultural adaptation in semi-arid regions.

Topic: Climate change – implications for strategies in policy and farming
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Is a green tax on red meat a feasible strategy to achieve Norwegian GHG-emission targets for agriculture?

Klaus Mittenzwei

Norway has decided to follow the EU in setting ambitious targets for reducing greenhouse gas (GHG) emissions from agriculture. The aim is to reduce GHG-emissions by 40 per cent by 2030. The paper discusses three policy measures to achieve this target in Norway: Reduced direct payments to red meat (beef, sheep, and lamb), a consumption fee for red meat, and informational measures that align red meat consumption with official public health recommendations.
The per capita consumption of red meat has shown a negative development in recent years. A continuation of that trend will positively contribute in the challenge to reach the emission target. However, there is currently a significant import of red meat that is expected to be reduced before domestic production eventually will fall.
Model results based on the sector model Jordmod indicate that all policy options have significant effects on Norwegian agriculture. The current level of the EU carbon tax is used as a proxy for the reduced direct payments and the consumption fee. The implicit amount of 410 (820) nkr per ton CO2-equivalent translates into a reduction of between 5 (7) per cent and is far from achieving the 40 per cent target. The result is partly based on some stickiness in the model that prevents an immediate fall in production due to lower profitability. A moderate change in the diet from red meat to white meat follows from the implementation of the policies. The consumption fee and the reduced payments have, in principle, the same effect on agriculture. This result relies on the assumption that import protection is no longer prohibitive at a commodity basis, and only partially prohibitive at the processed food level.

Topic: Climate change – implications for strategies in policy and farming
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Recovering the costs of irrigation water with different pricing methods under Climate Change: insights from a Mediterranean case study.

Cortignani, R., Dell'Unto, D., Dono, G.

Climate change (CC) is likely to increase water requirements of crops, and thus irrigation water uses. European Water Framework Directive (WFD) asks to fully cover the costs for water services, while minimizing adverse environmental, social and economic impacts. Preference is given to pricing instruments that establish a direct linkage between water use and cost, i.e. the volumetric system. In Italy, most of the irrigation schemes are managed by Reclamation and Irrigation Boards (RIBs). RIBs impose fees on the associated farmers usually aimed to cover only water distribution costs (WDC), through pricing systems often different from the volumetric. The present analysis focuses on an area of insular Italy (Sardinia), where a RIB supplies irrigation water to the associated farms. Currently, an area-based pricing system is adopted that makes farmers cover part of the WDC. The rest is supplemented by Regional Authorities with a contribution to compensate for local orographic and climatic disadvantages. Our objective is to assess the economic, social and environmental impacts of alternative pricing systems, including the volumetric, under a scenario of near-future (2020-2030) CC. The simulations deal with four levels of cost recovery, that start from the current level and gradually come to cover the full cost for water services. We do this through an economic model calibrated using Positive Mathematical Programming (PMP), that accounts for the abolition of milk quotas, the 2014-2020 CAP reform and the trend of expansion of bioenergy crops that affected the study area in the last years. The results are expected to provide local stakeholders and policy-makers with useful indications for implementing the WFD, while not discharging the issues related to an effective adaptation to CC.

Topic: Climate change – implications for strategies in policy and farming
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Observed impacts and adaptation in European cropping systems.

Olesen, Jørgen E.; Trnka, Mirek

The cultivation of crops, their productivity and quality, are directly dependent on different climatic factors. Climate change is already having an impact on cropping systems in Europe, and farmers and other agricultural stakeholders are considering how to adapt to the ongoing changes in climatic conditions. It is generally accepted that productivity of crops will increase in northern Europe due to a lengthened growing season and an extension of the frost-free period. In southern Europe, climate change is likely to negatively affect the productivity of crops and their suitability in certain regions primarily due to extreme heat events and an overall expected reduction in precipitation and water availability. Year-to-year variability in yields is generally expected to increase throughout Europe, due to extreme climatic events and other factors, including pests and diseases. There is a large variation across the European continent in climatic conditions, soils, land use, infrastructure, and political and economic conditions, which greatly influence the responsiveness to climatic change. Despite these many, diverse and ongoing effects of climate change in Europe, there is little consolidated evidence on how climatic change affects crops and cropping systems in Europe. Therefore, a questionnaire-based study of experts was initiated to give an overview of ongoing impacts and adaptations in European cropping systems. The study covers five major crops including wheat, oilseed rape, maize, potato and grapevine. The questionnaire takes individual European nations as the basis, but these are subdivided into environmental zones, and responses are sought for each environmental zone. We present initial findings of the questionnaire survey for major European crops.

Poster Presentations

MACSUR2017 Scientific Conference
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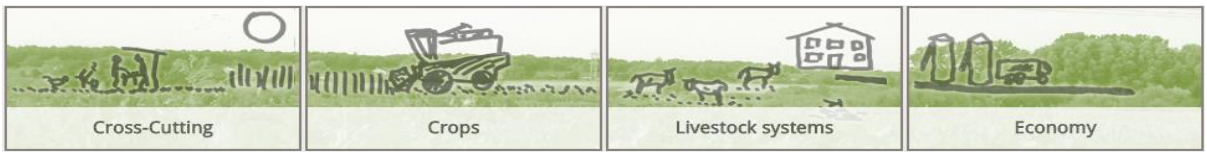

Topic: Improvements in modelling processes, interactions, and feedbacks
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Spatial analysis of multifractal spectra of the MERRA II meteorological time series.

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Temporal scaling properties of time series are important when applying climate change scenarios into crop growth models. For example, long time series with modification of their amplitudes, taking into account various climate change scenarios were used to analyse crop growth impacted by CO2 concentration changes and differences in management practices (Ruiz-Ramos et al. 2017). But any modification of the structure of the time series, e.g. by shifting amplitudes and oscillations, can also modify their underlying properties, such as long range correlations, therefore they should be done very carefully. Additionally, temporal scaling properties are vastly influenced by data aggregation. It should be taken into account when upscaling for large scale studies (Hoffmann et al. 2017). The meteorological time series from the Modern Era Retrospective-Analysis for Research and Applications (MERRA) were analysed using the Multifractal Detrended Fluctuation Analysis (MF-DFA) method for period 1979-2015 and in 248 grid points covering uniformly the Poland territory. MERRA combines observations distributed irregularly in space and time with an unchanging model and analysis system spanning the historical data record into a spatially complete gridded meteorological dataset (Rienecker et al., 2011), which may be used in large scale studies, such as scaling of crop growth model results. The MF-DFA is used for gridded daily air temperature, wind speed, wind direction and atmospheric pressure data and the objective of this study was to: a) verify whether, and to what extent multifractality occurs in the time series of meteorological variables from MERRA II data; b) compare the singularity spectra of the time series coming from different grid points spanned over Poland territory; c) analyse spatial patterns of multifractal properties and explain their similarities to the orographic features using geostatistical methods. The results show that MERRA II meteorological variables exhibit specific multifractal properties and spatial anisotropy.

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Topic: Improvements in modelling processes, interactions, and feedbacks
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Modelling the implications of variation in phenology and leaf canopy development for wheat adaptation to climate change.

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Crop models offer a great potential to quantitatively assess the impact of specific traits on crop yield and design ideotypes for target environments and future climatic conditions. The objectives of this study were to evaluate the capability of APSIM model for simulating two wheat cultivars contrasting in canopy development and phenology, and explore the implications of these traits for adaptation to climate change. A field experiment was conducted with a winter (Capo) and a facultative (Xenos) cultivar grown in Pannonian eastern Austria. Crops were sown at five sowing dates in 2013-14. Wheat yields ranged from 260 to 722 g m-2. Capo exhibited a more vigorous canopy growth and produced higher yields in autumn-sown plants, whereas Xenos performed better with spring sowing. The experimental dataset was used to parameterize the APSM model. While APSIM was capable of simulating the observed differences in phenology between the two cultivars, simulations of leaf canopy development were less accurate when the model default values for leaf appearance rate (phyllochron) and size were used. Adjusting these model parameters based on observed data improved the simulation results substantially. Thus, APSIM proved to be a robust modelling framework for capturing the differences in phenology and leaf canopy development in wheat and the resulting effects on crop water/N use and yield. The well-parameterised model was subsequently used to assess the potential value of genotypic variation in phenology and leaf canopy development for wheat adaptation to climate change by linking APSIM with climate change scenarios for the period 2035–65 in eastern Austria. The functional implications of variation in those plant traits on adaptation of wheat to future climatic conditions are discussed.

Topic: Improvements in modelling processes, interactions, and feedbacks
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Extending the BASGRA model for timothy grass with functions for simulating impacts of climate change and sward management on yield and nutritive value.

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1 Norwegian Institute of Bioeconomy Research (NIBIO), Norway
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Grass-based dairy and meat production constitute the economic backbone of agriculture in Northern Europe including Scandinavia. Timothy (Phleum pratense L.) is one the most important forage grasses in Sandinavia as well as in high latitude regions in North America and Japan. Grassland productivity is expected to be affected by climate change. Process-based models for weather dependent grass growth can assist farmers and plant breeders in adapting to climate change by simulating different options. These models can also be used to investigate different management options such as the prediction of the optimal harvest time for use in tactical planning at farm level under prevailing conditions. The BASGRA model was originally developed to investigate the interaction between the weather, soil and cutting regime on forage dry-matter yield. Recently, BASGRA was extended with functions for simulating nutritive value including crude protein, NDF fibres and fibre digestibility. The aim of this presentation is to give a brief overview of the new version of BASGRA, and to show an example of application of the model to multi-year simulation of timothy growth, yield and nutritive value at two sites in Norway under current and projected future climate conditions, including different fertilizer levels and cutting regimes. Information about the impact of climate change and management on sward nutritional value from such simulations is of particular importance to understand the interaction between these factors and livestock production, and thus to design livestock production systems for future climates.

Topic: Improvements in modelling processes, interactions, and feedbacks
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A new version of ORCHIDEE-GM with coupled carbon-nitrogen-phosphorus cycles: parameter calibration and model evaluation.

Jinfeng Chang, Philippe Ciais, Daniel S. Goll, Nicolas Viovy

The process-based biogeochemical model ORCHIDEE-GM is a version of ORCHIDEE land surface model that includes the grassland management module from PaSim. Accounting for the management practices such as mowing, livestock grazing and fertilizer application on a daily basis, ORCHIDEE-GM proved capable of simulating the dynamics of leaf area index, biomass, and C fluxes of managed grasslands. The previous versions of ORCHIDEE-GM did not include a full nitrogen cycle. The positive effect of nitrogen fertilizers on grassland photosynthesis rates was parameterized with an empirical function calibrated from literature estimate. In this study, ORCHIDEE-GM was merged into the ORCHIDEE-CN-P model, a version with coupled carbon-nitrogen-phosphorus cycles for terrestrial ecosystems. The new ORCHIDEE-GM model is capable to simulate the carbon, nitrogen and phosphorus fluxes among atmosphere, plant, livestock, and soil of managed grasslands. With some of its parameters calibrated, the new model was then evaluated at several grassland sites against eddy covariance fluxes, biometric measurements, and nitrogen-related measurements.

Topic: Improvements in modelling processes, interactions, and feedbacks
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Representative Agricultural Pathways (RAPs) for Austria: conceptual thoughts on its demand and stakeholder-driven development.

Schönhart, M., F. Sinabell, E. Schmid

Modelling communities in climate change research developed so-called Shared Socioeconomic Pathways (SSPs), which can be attributed to particular Representative Concentration Pathways (RCPs). SSPs are available at global to continental scales and describe major socio-economic developments. Such resolution is insufficient in particular for global to local mitigation, adaptation, and impact studies in agriculture. Hence, Representative Agricultural Pathways (RAPs) shall overcome this gap by developing narratives of plausible potential futures for the agricultural sector at regional to national scale. They should be consistent with SSPs and RCPs. These RAPs narratives are operationalized by variables and parameters usable in bio-physical and economic modeling of farms, landscapes and the agricultural and food sector.

In our presentation, we argue that there is demand of RAPs in local to regional land use studies up to the national scale. RAPs contribute to increase the consistency of climate change studies across scales and enhance harmonization of inputs and comparability of results. They are a service to the research community to save resources in scenario development. In the second part of the talk, we present a methodology for a stakeholder-driven design of RAPs. We refer to methodologies for RAPs-development in international studies and identify necessary deviations to take into account idiosyncratic features of Austria, which is our country of interest. Stakeholder engagement during the definition of RAPs may improve the acceptance of modelling results among practitioners and foster its implementation in policy processes. Besides, the process itself can stimulate a debate on the future of agriculture under climate change and its inherent uncertainties.

Topic: Improvements in modelling processes, interactions, and feedbacks
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Using crop modelling to determine the meteorological conditions to be implemented in an Ecotron facility - Prerequisites to improve the experimental design?

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An Ecotron is a facility where ecosystems are confined in experimental chambers, allowing the simultaneous control of environmental conditions and the on-line monitoring of processes. Under the threats of climate change and the pressure of a world growing population, such facilities will be of major importance to study the relations between climate change and agro-ecosystems.

As it can quickly become time- and money-consuming, conducting experiments in an Ecotron will force researchers to cautiously select the climate of interest to be generated. They will thus need reliable tools to help them support the decision making process.

Here, we present an innovative methodology, supported by the use of crop model, to assist researchers in finding the climatic conditions under which crop services will be impacted.

The meteorological datasets among which the choice can be made were generated by the ALARO-0 model (RMI, Belgium) for current and future climatic conditions. Runs were conducted for the historical period 1981-2010, and for two time frames - 2041-70 and 2071-2100 - under two emission scenarios - RCP 4.5 and 8.5.

A crop model (STICS, INRA, FR) was run over the entire database. Crop model outputs were synthesized for the main crop phenological phases, i.e. the juvenile, vegetative and reproductive phases. A particular emphasis was put on agronomical outputs (biomass and grain yield) and crop growth stresses (deficit and excess of water, thermal and nutrient stresses).

Using these outputs as selection criteria, a novel multi-criteria approach was designed to retro-select the specific climatic conditions allowing to reach certain outcomes (e.g. yield target) while simultaneously exhibiting given thresholds of stresses for any considered crop stages.

Topic: Improvements in modelling processes, interactions, and feedbacks
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The problem of a series of days without rainfall in a view of efficiency of agricultural output under climate change.

Bojar Waldemar, Knopik Leszek, Kuśmierek-Tomaszewska Renata, Żarski Jacek

Modelling future is key issue in studying CC impacts on agriculture across disciplines and scales. Improving models based on empirical data coming from diverse micro regions facilitate synergic effects important in promoting food security. Rainfall distribution is one of the most important factors determining agricultural output.
The amount of cereal yield depends on the occurrence of long series of days without rain during a growing season. Based on statistical analysis of daily precipitation totals it was found that in Central Poland the maximum length of dry spells during growing season is 40 days. Statistical analysis was done for years 1971-2015. The data allowed finding empirical probability distribution of series lengths. Average value of series lengths is 4.31 days while SD is 4.41 days. Parameter values of gamma distribution estimated by the likelihood method are: α=0.9542, β=4.5150. The value of the alpha parameter (shape parameter) suggests that the series length distribution is similar to an exponential distribution.
Goodness of fit test with gamma distribution was carried out using λ-Kolmogorov and χ2-Pearson tests. Both prove high confidence between empirical and gamma distributions. Assuming that gamma distribution can be accepted as distribution of dry spell lengths further is determined distribution of the length of the longest series in n-element random sample. In the theory of distributions of asymptotic order statistics it is known that the random variable T(n) with appropriate normalization has asymptotic double exponential distribution. Based on that one can conclude that probability of 30-day or longer rainless period equals approx. to 0.48. This is useful in forecasting agricultural output depended on rainfall distribution.

Topic: Advances in linking models in order to address impacts across scales or sectors
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Multi-model approach for assessing sunflower food value chain in Tanzania.

Elisa Vilvert, Marcos Lana, Stefan Sieber

Sunflower is one of the major oilseeds produced in Tanzania, but due to insufficient domestic production more than half of the country's demand is imported. The improvement of sunflower food value chain (FVC) is important to ensure an increase on production, availability and quality of edible oil in Tanzania. Therefore, a conceptual framework can allow the combined use of different models to provide insights about the sunflower FVC. This research focuses on identifying the European models participating in the MACSUR project that can provide a better understanding of the sunflower FVC in Tanzania, especially within a context of food security improvement. A FVC scheme for Tanzania was designed with the main steps of sunflower production. Thereafter, the models used in two MACSUR themes (CropM and TradeM) were selected and placed along each step of the FVC. As result, the sunflower FVC in Tanzania was organized in five steps, namely natural resources (1), production (2), processing (3), trade (4) and consumption (5). The step 1 uses environmental indicators to analyse soil parameters (calculated using LPJmL), and part of the outputs will provide data for the step 2 of the FVC. In the production step, data from step 1, together with other inputs, will be used to run crop models (as HERMES, MONICA and APSIM) to analyse the impact on sunflower yield. Thereafter, outputs from step 2 can be used as input for socio-economic models (as MODAM or MagPIE) to estimate production costs and profit (step 3) and also to determine the market opportunity for the sunflower oil and the by-products (trade and consumption). Due to the large range of models, it is possible to assess significant part of the FVC, reducing the necessity of assumptions and improving the understanding of the FVC.

Topic: Addressing uncertainty and risk in climate change impact studies
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Can we be certain about future land use change in Europe? A multi-scenario, integrated-assessment analysis.

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The global land system is facing unprecedented pressures from growing human populations and climatic change. However, the number of complex, interacting effects involved makes any complete understanding very difficult to achieve. Integrated modelling frameworks allows for the exploration of the co-development of human and natural systems under scenarios of global change. Here, we describe the use of one such integrated modelling framework (the CLIMSAVE Integrated Assessment Platform) to investigate the range of projected outcomes in the European land system across climatic and socio-economic scenarios for the 2050s. We demonstrate substantial consistency in locations and types of change even under the most divergent conditions, with results suggesting that climate change alone will lead to a contraction in the agricultural and forest area within Europe, particularly in southern Europe. This is partly offset by the introduction of socioeconomic changes that change both the demand for agricultural production, through changing food demand and net imports, and the efficiency of agricultural production. Sensitivity analysis of the land use change thresholds of between 0.1 and 25% within each grid cell demonstrates the robustness of the results. The very low likelihood (< 33% probability) that current land use proportions in many parts of Europe will remain unchanged suggests that future policy should seek to promote and support the multi-functional role of agriculture and forests in different European regions, rather than focusing on increased productivity as a route to agricultural and forestry viability.

Topic: Addressing uncertainty and risk in climate change impact studies
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Spatial aggregation for crop modelling at regional scales: the effects of soil variability.

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Modelling agriculture production and adaptation to the environment at regional or global scale receives much interest in the context of climate change (CC). One concern is to take into account the spatial variability of the environmental conditions (e.g. climate, soils, management practices) used as model input because the impacts of CC on cropping systems depend strongly on the site conditions [1]. For example CC effects on yield can be either negative or positive depending on the soil type [2]. Additionally, the use of different methods of upscaling and downscaling adds new sources of modelling uncertainties [3].
In the present study, the effect of aggregating soil data by area majority of soil mapping units was explored for regional simulations with the soil-vegetation model CoupModel for a region in Germany (North Rhine-Westphalia). Data aggregation effects (DAE) were analysed for wheat yield, water drainage, soil carbon mineralisation and nitrogen leaching below the root zone. DAE were higher for soil C and N variables than for yield and drainage and were strongly related to the presence of specific soils within the study region. These 'key soils' were identified by a model sensitivity analysis to soils present in the region. The spatial aggregation of the key soils additionally influenced the DAE. A spatial analysis of the pattern of these key soils (i.e. presence / absence, coverage and aggregation) can help in defining the appropriate grid-resolution that would minimize the error caused by aggregated soil input data in regional model simulations. In a second step the method will be applied and evaluated with respect to another European region (Tuscany) which is characterised by a warmer and drier climate.

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Topic: Addressing uncertainty and risk in climate change impact studies
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Comparing annual wheat yield sensitivity to climate at different sites using impact response surfaces.

Carter, T.R., N. Pirttioja, S. Fronzek

Impact response surfaces (IRSs) are plots that show the response of a dependent variable (the surface) with respect to two predictor variables. These have been used in recent studies to display wheat yield sensitivity to climate at sites in Europe across an ensemble of crop models. Results focused on period-averaged responses to a wide range of temperature and precipitation perturbations. However, these averaged responses may mask more complex year-to-year sensitivities.

In this study we used the IRS approach to investigate the sensitivity of both modelled and observed wheat yields to short-term (inter-annual) climate fluctuations in Finland, Germany and northern Spain. We focused on the baseline period (1981-2010) in order to gain insight into responses to present-day seasonal weather variations. Simulation results are from an earlier model ensemble inter-comparison exercise for sites in these countries (Pirttioja et al. 2015) for which co-authors are gratefully acknowledged. Observations are of yield statistics from regions in which sites are located.

IRSs were plotted with respect to annual temperature and precipitation anomalies from the baseline mean, using both statistical and interpolation methods. Preliminary results for IRSs of observed yields fitted using linear regression indicate some consistency in the association between annual yields and anomalies of annual temperature (negative) and precipitation (positive) compared to long-term responses reported previously. However, coefficients of determination are weak as yield responses are complex. Further analysis is focusing on non-linear regression models as well as interpolated surfaces for both observed and modelled yields.

Topic: Climate change adaptation and mitigation at the farm scale
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Crop Residue Management as a Strategy of Adaptation and Mitigation to Climate Change.

DomenicoVentrella, Luisa Giglio, Marco Bindi, Bruno Basso, Umberto Bonciarelli, Anna Dallamarta, Francesco Danuso, Luca Doro, Roberto Ferrise, Francesco Fornaro, Pasquale Garofalo, Fabrizio Ginaldi, Ileana Iocola, Paolo Merante, Laura Mula, Andrea Onofri, Simone Orlandini, Massimiliano Pasqui, Rodica Tomozei, Giulia Villani, Alessandro Vittorio Vonella, Pier Paolo Roggero

This paper reports the first results of a research developed in the context of the three-years (2013-16) research project "IC-FAR - Linking long term observatories with crop system modelling for better understanding of climate change impact and adaptation strategies for Italian cropping systems" (www.icfar.it).The goals are : i) to parameterize crop models considering two Long Term Agro-Ecosystem experiments (LTAE) located in experimental farms of Foggia (FG) and Papiano, Perugia (PG), in Southern and Central Italy, respectively and ii) to evaluate the crop residue (CR) management as a strategy of adaptation and/or mitigation to climate change forecasted for the reference areas of the LTEs in study. Climate scenarios were generated by setting up a statistical model using predictors from ERA40 reanalysis and seasonal indices of temperature and precipitation from E-OBS gridded data for the period 1958-2010. The statistical downscaling model was applied to CMCC-CM predictors to obtain climate projections at local scale over the period 1971-2000 and 2021-2050 (RCP4.5 and RCP8.5 emission scenarios).

Topic: Climate change adaptation and mitigation at the farm scale
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Web-based service of farm-level future climate and agro-information with RCP climate change scenarios.

Kyung Hwan Moon, Eun Young Song, In-Chang Son, Seung-Hwan Wui, Soonja Oh

For the farm-level adaptation against climate change, we developed web-based information services for future climate and related to agricultural production. Firstly we developed high-definition digital climate maps (DCMs) of RCP8.5 and RCP4.5 scenarios, which were made by a combination of dynamical and statistical downscaling methods. For the monthly DCM of 30-yr normals of 30m or 270m resolutions, produced using micro-climate models for spatial interpolation among weather stations, we added future anomaly maps from normals with RCP scenarios of 12.5km resolution of 10-yr intervals, provided by Korea Meteorological Administration (KMA). Those models of altitude, topology, cold-air accumulation, temperature inversion and urban effects were incorporated in micro-climate models for maximum and minimum temperature maps, and modified PRISM (Parameter-elevation Relationships on Independent Slopes Model) was used for precipitation maps. Also we analyzed changes on crop growing zones based on proper ranges of temperature and precipitation for crop growing seasons of some temperate crops, such as apple, pear, persimmon, grape, kiwi fruit, using monthly DCMs. All of these information was provided through internet site (www.agdcm.kr) by putting farm address on the web.

Topic: Climate change adaptation and mitigation at the farm scale
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Laboratory and field scale: two approaches for the evaluation of GHG emissions from dairy cows.

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The agricultural sector is an important contributor to emissions of greenhouse gases (GHG). At global scale GHG emissions from agricultural systems are estimated at 10-12% of the total anthropogenic emission. Modifying the diets of the dairy cows is a possible way to mitigate the emissions. Besides the methane (CH4) emissions from enteric fermentation, also the nitrous oxide (N2O) emissions from feed production have to be considered.

This study (INNO-Mil-CH4) aims to evaluate the GHG emissions in dairy farms, through the analysis of the effect of different diets on the emissions from dairy cows at laboratory scale and the use of a model to estimate the GHG emissions at real farm conditions. Twenty dairy cows were fed with four diets different for fiber and starch content and the addition of extruded linseed. CH4 emissions were measured in respiration chambers. In parallel, at field scale, data on cow diets, manure management, fertilization and milk production were collected from 21 farms located in three regions in Germany over a period of 24 months. CH4 and N2O emissions for each farm were estimated, and the effects of the dietary components and the farm management were evaluated and correlated to the emissions.
The results confirmed that CH4 emissions are strongly affected by the dry matter intake (DMI) and the linseed supplementation. A lower fiber and higher starch content in the diet reduced CH4 emission per kg milk by ~ 14%. The linseed supplementation (~ 8% of DMI) decreased CH4 emission per kg milk by ~ 12%. CH4 from enteric fermentation ranged between 12 and 15 g kg-1 milk-1 measured in the respiration chambers, and between 13 and 25 g kg-1 milk-1 estimated for the farm data. N2O emissions from feed production on the dairy farms ranged between 0.37 and 0.90 g kg-1 milk-1.

Topic: Climate change adaptation and mitigation at the farm scale
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Effects of nutrient supply on mitigation in a long-term experiment.

József Tibor Aranyos, Attila Tomócsik, Ibolya Demeter, István Henzsel, Marianna Makádi

The possible solutions for stopping climate change are important topics of research, industry and agriculture. In the last two centuries the carbon dioxide (CO_2) concentration has significantly increased due to human activity. About 20% of the greenhouse gases 5% of which is CO_2 come from agriculture. In order to mitigate the harmful impacts of climate change the CO_2 emission should be reduced in agriculture meanwhile the sector should supply the world's population with sufficient amount of good quality food.
In the project the calculation of soil carbon stocks, examination the effects of plant nutrition methods on carbon cycle and studying the possibilities of decreasing CO_2-emission based on the adaptation of plants were studied. The common research base allows soil and plant analysis connected to the carbon cycle in Westsik's crop rotation experiment which represents the typical farming systems of Eastern Hungarian Region, respectively the experiment is appropriate for studying long-term effects of farming (straw, farmyard, main and second crop green manure). The results could contribute to the development of methods for decreasing the quantity of CO_2 efflux from agriculture and for increasing the quantity of stored carbon in the soil. The experiences of study could support the development of new agrotechnical methods for conservation of organic matter content of soil and they could result in new innovations to decrease the sensitivity of crop lands to climate change.

Topic: Climate-related changes in environment, pests and diseases on agricultural production
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Effect of climate changes on plant disease under simulated conditions: challenges and limits.

Massimo Pugliese, Giovanna Gilardi, Angelo Garibaldi and Maria Lodovica Gullino

Increases in CO2 and temperatures are expected to induce complex effects on plant pathogens. Different approaches have been adopted to study the effect of climate on plant diseases, including laboratory and/or field studies, as well as modeling-based assessments and simulations under phytotrons. The impact of climate changes such as increased CO2 and temperature on pathogens affecting grapevine, basil, rocket, beet, lettuce, zucchini, radish, bean and geranium was assessed under phytotrons. Plants were grown under different simulated climatic conditions, at standard (400-450 ppm), average (600 ppm) and high (800 ppm) CO2 concentration and at standard (ranging from 18 to 22/24°C) and elevated temperature (4°C higher than standard). Variable effects were observed when individual parameters were taken into consideration. An increase of downy mildew on grapes, of powdery mildew on zucchini, of Alternaria leaf spot on rocket salad, of black spot on basil and of Phoma leaf spot on garden beet was observed when both CO2 level and temperature increased. Powdery mildew of grape was not influenced by increasing carbon dioxide and temperature. Downy mildew of basil and rusts of bean and geranium increased at higher CO2 levels, but only at lower temperatures, while the combination of high CO2 and high temperature lead to a reduction of the diseases. Regarding the effects of climate changes on Fusarium wilt of lettuce and rocket, the soil fungal and bacterial development was not affected by the different CO2 and temperature levels, while an increasing disease incidence was observed at high CO2 and high temperature, probably through plant-mediated effects. The role of phytotrons in the study of climate changes is discussed. This experimental approach could be relevant for developing models.

Topic: Climate-related changes in environment, pests and diseases on agricultural production
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Heat stress impact on productive efficiency and GHG emission intensity in dairy cow.

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In this study, we assessed the effect of heat stress on greenhouse gas emission (GHG) intensity (emissions produced per kg fat and protein corrected milk: FPCM in kilogram of carbon dioxide equivalents: kg CO2e) in dairy cows. A commercial farm milking about 1,100 cows/day was considered. Data on milk yield, fat and protein as percentage, number of cows milked for day and digestible energy and protein of diet were used to estimate the enteric methane emissions under heat stress and thermo-neutral scenarios using the IPCC-based equations. Temperature Humidity Index (THI) was calculated from data recorded in the nearest weather station and used to define heat stress conditions. Months of June, July, August, September and October showed an average maximum THI greater than 70 unit and were considered under heat stress, while the other months were considered as thermo-neutral. Productive parameters considered were 27.4 liter/cow/day; 3.8% and 3.2% under heat stress compared to 28.9 liter/cow/day, 3.7% and 3.3 % under neutral climate for milk yield and for fat and protein as percentage, respectively. Diet did not change during the periods studied then 73% of digestible energy and 16.7% of protein were considered for both scenarios. Methane emission intensity, was found as 0.400 and 0.388 kg CO2eq/kg FPCM for heat stress and thermo-neutral scenario, respectively. Under heat stress, emissions were12 grams CO2eq/kg FPCM or about 60 tonsCO2eq (considering the total milk yield in the study period) higher than that of thermos-neutral conditions. The preliminary results suggest that the effect of heat stress on the production efficiency may affect the emission intensity of GHG. However, further investigations are needed to well understand how heat stress modules enteric methane and others sources of GHG emissions in dairy cows. Therefore, a further study will focus on using HolosNor, a farm scale model, to account for all significant GHG emissions and to compare different levels of heat stress on farm GHG emissions.

Topic: Projecting climate change impacts on agriculture in European regions
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The impact of climate change on maize phenology in Poland under 10 different RCM scenarios.

Król, A., Kozyra, J., Żyłowski, T., Księżak, J., Liszewska, M.

Many of physiological processes that influence yield are heavily dependent on phenological development. Climate change will impact not only planting and harvesting dates of crops but also the length of particular phenological phases. Therefore, studying the impact of climate change on agriculture should begin with determining how climate change will affect crop phenology.

The aim of the study was to assess how maize phenology will change according to different RCM scenarios. The length of the development stages was estimated by phenological model implemented in the HERMES model. The model was calibrated and validated for silage maize varieties FAO 230-250 using a 13-year data set (2004-2016) from the experimental site located in Grabów (Masovian Voivodeship, Central Poland). Calibration has been made by establishment - in crop parameter file – of measured temperature sum for each development phase.

The analyses were performed for the time series from 1971-2050 from RCM scenarios biased, using local experimental data from the station located at experimental site. The RCM simulations were represented by ten Regional Models based on five different Global Models. Two Representative Concentration Pathways (RCP 4.5 and RCP8.5) were analysed and compared.

Based on RCP4.5 the mean monthly air temperature for period from April to September will increase by 1.1˚C while RCP8.5 predicts a 1.2˚C rise for 2030. But for the individual RCM scenarios, the changes in monthly mean air temperature from April and September for RCP 4.5 range from 0.5˚C to 1.5˚C, whilst for RCP 8.5 between 0.6˚C and 1.7˚C. The obtained results demonstrate how using different RCM and its biasing can impact on maize phenology. For example, based on analysed RCP 4.5 and RCP 8.5 scenarios for 2030, the shortening of the period from sowing to flowering, according to analysis for scenarios with the highest rise in temperature, amount to 4 and 3 days respectively, whilst based on scenarios with the smallest temperature changes for RCP 4.5 there are no significant changes in this period. In the analysis conducted for the period from sowing to grain filling, according to RCP 4.5 the shortening of those phase based on analysis scenarios with the highest and the smallest rise in temperature phase varied from 5 to 8, and for RCP 8.5 from 4 to 7 respectively.

Topic: Projecting climate change impacts on agriculture in European regions
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Wheat grain yield and water use efficiency improved under climate change condition in semi-arid regions as predicted by APSIM crop model.

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The present study investigated the effect of climate change on crop productivity and water use efficiency at the regional scale. A general circulation model (HadCM3) was applied for two emission scenarios (A1B and A2) for three periods (2011-30, 2046-65 and 2080-2099) at nine locations in Fars province in central Iran. The APSIM crop model was used to simulate growth and development of wheat as well as water use efficiency under future climate scenarios. The results indicated that average temperature over the growing season increased from 12.15°C at baseline to 13.22°C in average of the future projections. The increase in CO2 concentration to 674 ppm in 2099 under the A1B scenario eliminated the negative effects of high temperature during the growing season and improved crop yield. Wheat grain yield increased from +10 to +41% over baseline for all future emission scenarios and periods at all study locations. The results indicate that by the end of the century under the A2 emission scenario 10% to15% of Fars province will have a grain yield of more than 10 t ha-1 and about 65% will have a grain yield of 8 to 10 t ha-1. Averaged across locations, scenarios and periods, water use efficiency increased by 3.56 kg ha−1 mm−1 in the future scenarios over baseline. The improved water use efficiency under future climate change was largely the result of a significant increase in yield (from 6989 kg ha−1 at baseline to 8416 kg ha−1 in average of the future projections) and decreased evapotranspiration (from 506.8 mm at baseline to 478 mm in average of the future projections). A decrease in evapotranspiration as well as an increase in water use efficiency under future climate could be beneficial for agricultural production systems, particularly under semi-arid conditions.

Topic: Projecting climate change impacts on agriculture in European regions
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User co-design of state-of-the-art climate simulations: towards a better-informed agricultural sector.

Eveline C. van der Linden 1, Janette Bessembinder 1, Dragana Bojovic 2, Erika Palin 3, Galina Guentchev 3, Isadora Christel 3

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3 Met Office Hadley Centre (UKMO)

Trustworthy projections of climate change are important for the European agricultural sector in order to respond and adapt to climate change. However, a common barrier to the use of climate information is a lack of understanding by users of what information can reasonably be provided by state-of-the-art climate science, and by climate scientists of what information is required by users in order for it to be usable in research and practical decision-making. The PRIMAVERA ("PRocess-based climate sIMulation: AdVances in high-resolution modelling and European climate Risk Assessment") project addresses this by applying a co-design approach aiming to tailor its scientific outputs to the user needs, whilst ensuring that scientific integrity is maintained and avoiding over-interpretation.
The main outputs of PRIMAVERA will be high-resolution (~25 km) simulations with global climate models, an assessment of the ability of these models to simulate societally important processes, and high-resolution climate model projections supporting European climate risk assessment activities. With these high-resolution simulations several aspects of climate and climate change will expectedly be simulated much better compared to traditional resolution (~125 km) models, such as the location and intensity of European wind storms and associated rainfall. Higher-resolution (both spatial and temporal) projections are vital to assess how the risk of the high-impact climate events that influence food production, such as heat waves, floods, and droughts, is projected to change over the next few decades.

Topic: Projecting risks and opportunities for farming and food production in regional case studies
Submitting author: Beckers, Veronique
E-mail address: veronique.beckers@unamur.be
Affiliation: University of Namur, Belgium

Land surface interactions modeling (Agent-Based Model – Dynamic Vegetation Model) over Belgium: current state and crop yield assessment for future (at the Belgian and European scales).

Jacquemin, I., Beckers, V., Henrot, A-J., Berckmans, J., Hamdi, R., François, L., Dendoncker, N.

Agriculture in Europe is under substantial pressure. Farmers need to adapt to an ever-increasing global market, resulting in increasing competition and a high dependency on global food prices. Furthermore, they have to deal with an increasing urbanization pressure and to comply with increasingly strict environmental rules and policies, sometimes requiring heavy investments. Combined to potential impacts of climate changes on ecosystems functions and structures, these factors could lead to a change in land use structure.

In the framework of the MASC project ("Modelling and Assessing Surface Change impacts on Belgium and Western European climate"), we aim at providing a better understanding of these factors, with the final objective of improving regional climate model projections at the decennial scale over Belgium and Western Europe by combining high-resolution models. We propose to combine an agent-base model (ABM) and a dynamic vegetation model (DVM), CARAIB ("CARbon Assimilation In the Biosphere"). The ABM models the farmers as individual agents using a certain number of parcels. They decide on what to plant based on market prices, subsidies, crop rotations, personal preferences and the expected yield, which will be given by CARAIB.

CARAIB will be forced over Belgium with the outputs of the regional climate model ALARO (4 km resolution) for the recent past and for the most common crops. As a first attempt to assess the impact of the climate change on crops yields over Europe, CARAIB will be driven with the outputs of several regional climate models (RCMs), from EURO-CORDEX, nested in CMIP5 general circulation model projections: ALADIN53 (Météo-France/CNRM), RACMO22E (KNMI), RCA4 (SMHI) and REMO2009 (MPI-CSC) RCMs (0.11-degree, ≈12 km)

Topic: Projecting risks and opportunities for farming and food production in regional case studies
Submitting author: Glemnitz, Michael
E-mail address: mglemnitz@zalf.de
Affiliation: Leibniz Centre for Agricultural Landscape Research (ZALF) e.V., Germany

Regional adaptation of crop rotations as key factor to improve sustainability - integrative assessment of agricultural, ecological and economic impacts.

Glemnitz, M., C. Peter, J. Aurbacher, P. Kornatz, P. Graf, J. Eckner, M. Heiermann, J. Müller

Recent impact assessments add to growing evidence that the environmental effects of cropping interact with the regional landscape. Not only the environmental risks are unevenly distributed regionally but also the agricultural feasibility and economic attractivity of cropping options. Farmers act divergently depending on the respective soil quality of their land. Moreover counter measures to reduce negative impacts of single cropping practices have a varying efficiency at different regions. Thus sustainability of cropping systems call for both integrative assessments over different kinds of indicators and for considering their regionality through regional adaptation.
Our paper presents a methodology for a comparative, data driven impact analysis which was developed in the project EVA. Plot experiments on up to nine different crop rotations build the core of the research. The assessment on the ecological effects of various cropping options within the EVA project was based on empirical data gained from plot trials at ten different experimental sites across Germany. The ecological effects have been assessed by using different well established agro-ecosystems models. Data elevation at the experimental plots followed an unified, standardized protocol (methods hand book). Based on the experimental trial data an indicator set comprising 5 agricultural, 17 different single ecological and 4 economic indicators as well as 4 indicators addressing different aspects of resource efficiency have been calculated.
Our results address the main process drivers and their interactions. The present work demonstrates that the design of CRs and regional adopted management practices can be an appropriate steering option improving sustainability in land use management.

Topic: Novel impacts from climate change, new approaches for adaptation and mitigation
Submitting author: De Swaef, Tom
E-mail address: tom.deswaef@ilvo.vlaanderen.be
Affiliation: ILVO Plant Sciences Unit

Simulation of perennial ryegrass quality traits using PaSim in a breeding context.

De Swaef T., G. Bellocchi, J. Aper, P. Lootens, I. Roldán-Ruiz

Forage quality is important for an efficient uptake and digestion by ruminants. Factors that may limit the animal's ability to reach production goals (high nutritional value of milk and meat) may include the forage's energy and protein content. Moreover, a balanced energy/protein feed can contribute to reduce greenhouse gas emissions from forage protein during digestion. Together with dry matter yield, several quality traits are used as selection criteria in breeding programs of perennial ryegrass (Lolium perenne L.). Though the different components of forage quality have a genetic basis, quality traits are strongly influenced by environmental conditions and their expression varies over the growing season. Consequently, the selection progress is often slow for quality traits because the appreciation of a candidate variety differs largely across years and locations.

Modelling approaches can assist here. We refer to the vegetation module of the grassland model PaSim, which simulates different quality traits in response to growing conditions. We investigated whether PaSim can explain the variation in quality traits of candidate varieties of perennial ryegrass throughout the year, and whether model parameter values can be set to characterize each candidate variety.

For that, we used a wide set of observations from 65 candidate varieties of the ILVO perennial ryegrass breeding program started in 2012. Observed data from five cutting events in 2013 include: dry matter yield, crude protein content, water soluble carbohydrate content, neutral detergent fiber content (NDF, i.e. cell wall content) and digestible neutral detergent fiber content (NDFD, i.e. cell wall digestibility). Dry matter yield data were also measured in 2014. Model parameter values were estimated for each candidate variety, based on observations and using the parameter optimization function of Package-FME–R Project.

This allowed us assigning a set of parameter values to each candidate variety, which can now be evaluated in virtual experiments for a better appreciation of the candidate varieties.

Topic: Climate change – implications for strategies in policy and farming
Submitting author: Drastig, Katrin
E-mail address: kdrastig@atb-potsdam.de
Affiliation: Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB) , Germany

Does the effect of the choice of crops has a stronger influence on regional water resources than those of climate variability?

Drastig K., Prochnow A., Libra J., Koch H., Rolinski S.

The amount of irrigation water used is increasing in many regions worldwide, including regions in Germany that are characterized with low precipitation levels, yet grow water-demanding crops such as sugar beets, potatoes, and vegetables. This study analyzes the spatial and temporal changes in the irrigation water demand (IWD) of the four crops spring barley, oat, winter wheat, and potato in Germany. The IWD, the amount of water that has to be applied in addition to rainfall to meet crop water needs, was calculated using the modeling software AgroHyd Farm model for the years 1902 to 2010. During these 109 years, the political borders, land area, as well as the available data changed substantially. Land areas for the modeling process were defined by deriving 153 districts from the administrative districts of historical maps.
Climatic conditions in Germany continued to change over the investigation period, with an increase in temperature of 0.01 K/yr and an increase in precipitation of 1 mm/yr. Nevertheless, no significant increasing or decreasing trend in IWD was noted in the analysis. The IWD for the investigated crops in the area of the current "Federal Republic of Germany" over the 109 years was 112 mm/yr, varying between 100 and 127 mm/yr. Changes in cropping pattern and cultivated area over the last century caused large differences in the IWD calculated for each administrative district. The mean annual IWD of the study period (which was divided into 4 parts) varied between 13,455 Mm³/yr in the earliest period (1902 -1919) and 4,717 Mm³/yr in the latest period (1990 -2010).
Cropping pattern is of high importance to the expected local and temporal water scarcity in the future.

Topic: Climate change – implications for strategies in policy and farming
Submitting author: Margaryan, Varduhi
E-mail address: vmargaryan@ysu.am
Affiliation: Yerevan State University, Faculty of Geography and Geology, Yerevan, Armenia

Assessment of viticulture and winemaking vulnerability in the expected conditions of climate change in Ararat valley and foothills.

Varduhi Margaryan 1, Mariam Mkhitaryan 2

1 Yerevan State University, Faculty of Geography and Geology, Yerevan, Armenia.
2 Ministry of Emergency Situations of the Republic of Armenia, SHAIAP

The work aims to study and analyze climate changes in the study area, to discuss and estimate the vulnerability of climate change on viticulture and wine-making, to work out the ways of climate change prevention, reduction of negative effects and adaptation. For solving these problems, theoretical and Informational bases are appropriate studies, particularly, the works about climate change, long-term development programs, projects, and decisions of the government, reports. As a source material, actual agrometeorological observations data of the Ministry of Emergency Situations of the Republic of Armenia "Service for Hydrometeorology and active influence on atmospheric phenomena" and the data of the RA National Statistical Service have been used. As a methodological basis, the following were used: characterization, geographical and statistical analyses, physical - mathematical analyses, extrapolation and correlation methods.

The result of studies showed that in the study area a tendency of frequency increase of the temperature and heat-providing is observed, as well as evaporation, dangerous meteorological phenomena. As a result, in the conditions of expected increase of temperature, grape cultivation vegetation begins earlier and ends later, that is, increases the duration of vegetation period. On one hand, favorable heat conditions are created for viticulture, on the other hand, the degree of viticulture vulnerability grows to meteorological and agrometeorological unfavorable phenomena and dangerous events.

Note, that in Ararat valley brandy wine material, fortified sweet, dry table wines and grape`s juice production have been specialized. Such climate change will lead to the sharp increase of sugar in grapes, which will not be appropriate to the standard requirements. In the result, in this zone it will be difficult and impossible to implement the industry of table dry wine materials. Cultivation of these varieties should be moved to the foothills.

On the other hand, it should be noted that the analyses of statistical service data shows, that not only the study area, but also the entire area of the Republic a growth of gross harvest and yield is observed during 2000-2015. But it does not means that viticulture is not vulnerable to impact of climate change.

So, this does not mean that viticulture is not vulnerable to the impacts of climate change. Thus, the combination of temperature, increase and precipitation decrease will bring to additional irrigation water demand, secondary soils salinization, reducing the effectiveness of grape, and therefore, to cost increase. So, it is necessary to make a serious scientific research, work out a new strategy, find new areas for vineyards and work out more new productive varieties for these conditions.

Topic: Climate change – implications for strategies in policy and farming
Submitting author: Margaryan, Varduhi
E-mail address: vmargaryan@ysu.am
Affiliation: Yerevan State University, Faculty of Geography and Geology

The vulnerability and risk assessment of agricultural crops in the conditions of expected climate change in the Republic of Armenia.

Varduhi Margaryan 1, Gohar Guloyan 2

1 Yerevan State University, Faculty of Geography and Geology, Yerevan, Armenia.
2 Ministry of Emergency Situations of RA, "Armhydromet" "Service for Hydrometeorology and active influence on atmospheric phenomena".

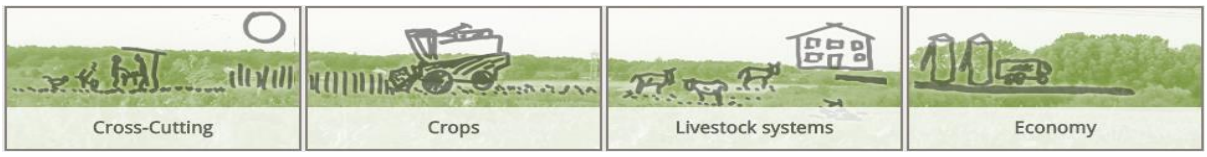
The work aim is to study and to analyze climate change impacts in the study territory, to discuss and to assess the vulnerability of agricultural plants of the area to climate change, as well as to develop ways for prevention, reduction of negative consequences and for adaptation under climate change. Relevant studies, in particular works on climate change, development programs, projects, decisions of the Government of Armenia, as well as reports have become information source and theoretical basis for solutions of the suggested issues. As a source material, actual data of agro meteorological observations of Armhydromet acting under the Ministry of Emergency Situations and data of the National Statistical Service of Armenia have been used. In the work, as a methodological bases, the methods of description, statistical analysis, physical and mathematical analysis, extrapolation and correlation have been utilized.

Studies show that according to the actual observed data, mainly increasing trend of the average annual values of air temperature is observed in the territory of Armenia and in some of its regions, the changes are considerable. It should be mentioned, that the maximum rate of increasing temperature are obvious in the summer. As for precipitations, it should be mentioned, that according to the observed years, there is not any perceivable systematic change of precipitation in the study territory, as there are both decrease and increase trends of annual quantity of precipitation. However, it should be mentioned that a considerable decrease of precipitation quantity could be expected in the summer. Thus, in the greatest part of regions of Armenia the summer (consequently also vegetation period) could be described by the increase of hot and dry weather conditions. It will become worse because of the influence of climate change and will lead to raising various problems in the spheres of water industry, agriculture, energy, health, etc.

The data analysis of the National Statistical Service shows, that in the area of the Armenia increase of gross harvest of agricultural plants, except tobacco, and their fruitfulness has been observed in the 2000-2015 period. However, it does not mean that agricultural plants are not vulnerable to the impacts of climate change. It only needs complex and coordinated studies and complex implementation measures.

Programme

MACSUR2017 Scientific Conference
22-24 May, 2017
Berlin



MACSUR2 FINAL CONFERENCE IN BERLIN: 22-24/05/2017

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<tr><td>22/05/2017</td><td>23/05/2017</td><td>24/05/2017</td></tr>
<tr><td rowspan="3">09:00-12:00 Pre-conference meetings:
• Sustainable Intensification Workshop
• Workshop on model comparison and improvement (XC1)
• Project Steering Committee (10:00-12:00)</td><td>09:00-10:30 2nd Plenary
Chair: Heidi Webber
Keynote: Marco Bindi, CropM overview
Keynote: Nigel Scollan, LiveM overview
Keynote: Franz Sinabell, TradeM overview</td><td>09:00-10:20 3rd Plenary
Chair: Jørgen E. Olesen
Keynote: Martijn Buijsse, European Initiative for Sustainable Development in Agriculture
Keynote: Pier Paolo Roggero, Case Study summary</td></tr>
<tr><td>10:30-11:00 Coffee Break</td><td>10:20-10:50 Coffee Break</td></tr>
<tr><td>11:00-12:40 Parallel sessions (4×5 presentations)</td><td>10:50-12:10 Parallel sessions (4×4 presentations)</td></tr>
<tr><td>12:00-13:15 Registration</td><td>12:40-13:50 Lunch Break
• Lunch meeting 1: IRS group
• Lunch meeting 2: EU CGRA</td><td>12:10-13:50 Lunch Break</td></tr>
<tr><td>13:15 Welcome
Dr. Hartmut Stalb, German Ministry of Food and Agriculture (BMEL), Chair of the FACCE Governing Board</td><td>13:50-15:30 Theme meetings
• CropM: CropM overview of scientific outcomes and future views (WPs 1-4)
• CropM: Special theme meeting for WP6 "Case studies, stakeholder involvement"
• LiveM: Livestock & grassland challenges in MACSUR 3
• TradeM: Economic and trade issues for MACSUR3</td><td>13:50-15:00 4th Plenary
Chair: Jørgen E. Olesen
Keynote: Tania Runge, former chair of the FACCE JPI Stakeholder Advisory Board

Plenary: summaries of Theme meetings on Tuesday (10' each)</td></tr>
<tr><td>13:30-14:50 1st Plenary
Chair: Claas Nendel
Keynote: Frank Ewert:
Agriculture, climate change and food security – progress and challenges in systems research and integrated assessment and modelling
Keynote: Martin Banse and Reimund Rötter:
Multi-scale Modelling of Adapting European Farming Systems</td><td>15:30-16:00 Coffee Break</td><td rowspan="5">15:00-15:30 Coffee Break

15:30-17:00
Plenary: MACSUR2++ strategy and actions: presentations and discussions
FET Flagship preparations</td></tr>
<tr><td>14:50-15:10 Coffee Break</td><td rowspan="4">16:00-17:30 Poster Session
(CropM WP leaders meeting)</td></tr>
<tr><td>15:10-16:10 Parallel sessions (4×3 presentations)</td></tr>
<tr><td>16:10-16:30 Coffee Break</td></tr>
<tr><td>16:30-17:30 Parallel sessions (4×3 presentations)</td></tr>
</table>

Date/Time	Monday, 15:10 – 16:10 and 16:30 – 17:10	
Panel ID	Parallel1/1	
Room	BUNSEN	
Panel motto	"In God we trust, all others must bring data" – W. Edward Deming	
Chair	Pierre Martre	
#	Title	Presenter
1	Comparing the site sensitivity of crop models using spatially variable field data from precision agriculture.	Kersebaum, Kurt Christian
2	How is crop growth model calibration performed? Results of a survey.	Seidel, Sabine Julia
3	Implications of input data aggregation on upscaling of soil organic carbon changes	Grosz, Balázs
4	Assessment of soil and climate change data aggregation impact on crop yield simulation: from local to regional study in NRW, Germany	Maharjan, Ganga Ram
5	Contribution of uncertainties from model structure, parameters and climate scenarios in climate change impact projections	Tao, Fulu

Date/Time	Monday, 15:10 – 16:10 and 16:30 – 17:30	
Panel ID	Parallel1/2	
Room	PASTEUR	
Panel motto	"We are moving from a chain of command to a web of connection, from competition to collaboration, from markets to networks and stockholders to stakeholders, and greed to green." – Anodea Judith	
Chair	Richard Kipling	
#	Title	Presenter
1	Targeting and prioritization of interventions for reducing enteric methane emissions: findings and lessons from 13 countries.	Opio, Carolyn
2	Developing a framework for critical assessment of stakeholder engagement activities.	Kipling, Richard
3	Wanting it all - is a stakeholders' Vision for Europe compatible with meeting Europe's food demand under climate change?	Holman, Ian
4	Integrating the impact of climate change, price changes and recent CAP orientation on Mediterranean farming systems	Cortignani, Raffaele
5	A scenario-neutral approach to understanding the regional land use change and food supply consequences of future climate and socio economic change.	Sandars, Daniel
6	Assessing the Importance of Accounting for the Impacts of Global Climate Change on Relative Competitiveness and International Trade in the Agricultural Sector	Beach, Robert

Date/Time	Monday, 15:10 – 16:10 and 16:30 – 17:30	
Panel ID	Parallel1/3	
Room	EINSTEIN	
Panel motto	“Sustainability is no longer about doing less harm. It's about doing more good.” – Jochen Zeitz	
Chair	Franz Sinabell	
#	Title	Presenter
1	Sustainable agricultural intensification: indicators and metrics for multi-scale modeling.	Mouratiadou, Ioanna
2	Assessing priorities for enhancing adaptive capacity of agricultural systems to climate change using fuzzy logic-based approaches	Seddaiu, Giovanna
3	How to achieve higher yield levels in North Savo – means and challenges indicated by farmers.	Lehtonen, Heikki
4	Climate-neutralizing managed landscapes in Sweden.	Olin, Stefan
5	Modelling the impact of rural frontier migration on tropical deforestation.	Van Rompaey, Anton
6	Watch It Grow, an innovative platform for a sustainable growth of the Belgian potato production.	Curnel, Yannick

Date/Time	Monday, 15:10 – 16:10 and 16:30 – 17:30	
Panel ID	Parallel1/4	
Room	NEWTON	
Panel motto	“Farming is a profession of hope” – Brian Brett	
Chair	Kairsty Topp	
#	Title	Presenter
1	Creating a dynamical farmer population model at country scale level.	Beckers, Veronique
2	How does the projected climate change impact on dry matter yields, greenhouse gas emissions and economics in Norwegian dairy farming systems?	Özkan Gülzari, Şeyda
3	Rethinking farm-scale modelling to meet new challenges and possibilities	Hutchings, Nicholas
4	Tools to support farmer decision – making in arable cropping systems.	Topp, Kairsty
5	Future climate change, yield variation, and impacts on farm management: a case study at a pilot regions in Finland	Purola, Tuomo
6	Does collaborative farm-scale modelling address current challenges and future opportunities?	Hutchings, Nicholas

Date/Time	Tuesday, 11:00 – 13:00	
Panel ID	Parallel2/1	
Room	BUNSEN	
Panel motto	“The pure and simple truth is rarely pure and never simple” – Oscar Wilde	
Chair	Taru Palosuo	
#	Title	Presenter
1	Integrated modelling of agricultural adaptation and the value of precipitation information in a semi-arid Austrian region	Karner, Katrin
2	Integrated assessment of farm level adaptation in Flevoland, the Netherlands: what did we learn from multiple methods and model chains?	Reidsma, Pytrik
3	Observed impacts and adaptation in European cropping systems	Olesen, Jørgen E.
4	Integrated Impact Modelling of climate change and adaptation policies on land use and water resources in Austria	Schönhart, Martin
5	Modelling climate change adaptation in European agriculture: Challenges and priorities.	Topp, Kairsty
6	Assessing the role of farm-level adaptation in limiting the local economic impacts of more frequent extreme weather events in Dutch arable farming systems.	Diogo, Vasco

Date/Time	Tuesday, 11:00 – 12:40	
Panel ID	Parallel2/2	
Room	NEWTON	
Panel motto	“The Soil is the gift of God to the living.” – Thomas Jefferson	
Chair	Heikki Lehtonen	
#	Title	Presenter
1	Drivers and trends for agricultural soil management – a foresight study for Germany	Helming, Katharina
2	Assessment of climate change impacts on SOC dynamic in rainfed cereal cropping systems managed with contrasting tillage practices using a multi model approach	Iocola, Ileana
3	Modelling the impact of soil management on soil functions.	Vogel, Hans-Jörg
4	Impacts of Climate Change Adaptation Options in Agriculture on Soil Functions: Examples from European Case Studies	Hamidov, Ahmad
5	Modelling nitrous oxide emissions of high input maize crop systems	Roggero, Pier Paolo

Date/Time	Tuesday, 11:00 – 12:40	
Panel ID	Parallel2/3	
Room	EINSTEIN	
Panel motto	“Moo may represent an idea, but only the cow knows.” – Mason Cooley	
Chair	Jantine Van Middelkoop	
#	Title	Presenter
1	Influence of environmental climate conditions on animal welfare criteria of lactating dairy cows	Siemens, Theresa
2	Spatially explicit estimation of climate change related heat stress on the milk production of dairy cows in the United Kingdom	Fodor, Nándor
3	Process-based modelling of the nutritive value of forages: a review.	Virkajärvi, Perttu
4	The feed story for dairy production systems under climate change	Bannink, André
5	Comparing the performance of nutritive value predictions in three timothy models	Persson, Tomas

Date/Time	Tuesday, 11:00 – 12:40	
Panel ID	Parallel2/4	
Room	PASTEUR	
Panel motto	“Assessment is today’s means of modifying tomorrow’s instruction.’ – Carol Ann Tomlinson	
Chair	Tommy Dalgaard	
#	Title	Presenter
1	Observed Crop-Yield Response Economic and Agro-climatic Factors in Austria - a Spatial Analysis	Marton, Tibor
2	Recovering the costs of irrigation water with different pricing methods under Climate Change: insights from a Mediterranean case study	Dell'Unto, Davide
3	What are the risks of food price changes? A time series analysis.	Hoveid, Øyvind
4	Is a green tax on red meat a feasible strategy to achieve Norwegian GHG-emission targets for agriculture?	Mittenzwei, Klaus
5	Multi-criteria tools for the assessment and implementation of geographically targeted measures to mitigate nutrient losses and adapt to climate change - examples from Denmark	Dalgaard, Tommy

Date/Time	Wednesday, 10:50 – 12:10	
Panel ID	Parallel3/1	
Room	NEWTON	
Panel motto	“Statistics is the grammar of Science.” – Karl Pearson	
Chair	Gianni Bellocchi	
#	Title	Presenter
1	Probabilistic assessment of adaptation options from an ensemble of crop models: a case study in the Mediterranean	Ferrise, Roberto
2	When and why to predict using the mean or median of a crop multi-model ensemble	Wallach, Daniel
3	Sensitivity of a grassland model ensemble to climate change factors: the MACSUR approach.	Bellocchi, Gianni
4	Effect of changing size and composition of a crop model ensemble on impact and adaptation response surfaces	Rodríguez, Alfredo

Date/Time	Wednesday, 10:50 – 12:10	
Panel ID	Parallel3/2	
Room	PASTEUR	
Panel motto	“We have decisively changed the carbon cycle, … and the rate of extinction.” – Rob Nixon	
Chair	Daniel Sandars	
#	Title	Presenter
1	Opportunities for soil carbon sequestration under old and new grazed grassland in the Netherlands.	Van Middelkoop, Jantine
2	Comparison of two calibration levels on the simulation of soil water content using nine crop models under different rotation schemes in five European sites.	Lana, Marcos
3	Effects of grassland management on the global carbon cycle.	Rolinski, Susanne
4	Modelling of carbon cycle in grassland ecosystems of diverse water availability using Biome-BGCMuSo.	Lellei-Kovács, Eszter

Date/Time	Wednesday, 10:50 – 12:10	
Panel ID	Parallel3/3	
Room	EINSTEIN	
Panel motto	“All models are wrong, but some are useful.” – George E.P. Box	
Chair	Christian Kersebaum	
#	Title	Presenter
1	Evaluation of CERES Wheat and Rice Model for changing Climatic Conditions in Haryana, India	Rana, Mamta
2	Modelling production and environmental impacts of perennial cropping systems with the STICS model	Strullu, Loïc
3	Increasing wheat yield potential and stability under climate change will require tolerance to drought during reproductive development	Semenov, Mikhail
4	Modelling plant disease and pest effects on crop performances.	Kersebaum, Kurt Christian

Date/Time	Wednesday, 10:50 – 12:10	
Panel ID	Parallel3/4	
Room	BUNSEN	
Panel motto	“The noblest pleasure is the joy of understanding” – Leonardo da Vinci	
Chair	Tommaso Stella	
#	Title	Presenter
1	A pan-European analysis of the spatio-temporal patterns of yield gap and abiotic stresses for wheat	Martre, Pierre
2	Yield gaps of cereals across Europe.	Schils, René
3	Using impact response surfaces to analyse the likelihood of impacts on crop yield under a changing climate.	Pirttioja, Nina
4	Recent advances in integrated assessments of climate change impacts on European agriculture.	Webber, Heidi

Conference Organising Committee

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