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**The state-contingent approach to production and choice under uncertainty: usefulness as a basis for economic modeling**

*Denitsa Angelova (IAMO)*

The state-contingent approach developed by Chambers and Quiggin (2000) constitutes an attractive blend of a theory of production analysis under uncertainty and a theory of decision-making under uncertainty.

One of the goals of this contribution is to introduce the reader to the approach by outlining its contents while comparing and contrasting it to related theories. With respect to production analysis: an emphasis is made on the ability of the approach to deliver well defined cost functions corresponding to stochastic production technologies. With respect to decision-making under uncertainty: the comparison with other theories consistent with a rational agent emphasizes the production theoretical basis of the state-contingent approach.

It is the author's belief that appropriately categorizing the state-contingent approach serves the primary goal of this work: to explore its usefulness as a basis for economic modeling. Some challenges regarding an empirical implementation are discussed: challenges in estimating the parameters of a state-contingent technology representation in general, as well as challenges arising from the fact that the approach is constructed around the argument pioneered by Leonard J Savage: that probabilities underlying economic decision-making are inherently subjective.

(The financial support of ScienceCampus Halle is gratefully acknowledged.)

**Climate change impacts on natural pasturelands of Italian Apennines**

*Giovanni Argenti (Department of Agri-Food Production and Environmental Sciences (DISPAA))*; *Francesco Catolfi (University of Florence)*; *Marco Moriondo (IBIMET-CNR)*; *Nicolina Staglianò (Department of Agri-Food Production and Environmental Sciences (DISPAA))*; *Marco Bindi (Department of Agri-Food Production and Environmental Sciences (DISPAA))*

As well as the entire Mediterranean area, the Italian Apennines have been affected by increasing temperatures, rainfall extreme events and decreases in annual precipitation due to climate change. Moreover, permanent grasslands, species-diverse ecosystems characterizing the marginal areas of the Apennines landscape, are acknowledged as very sensitive and vulnerable to climate variation. Building on these premises, statistical classification models coupled with data integration by GIS techniques, were used to territorially assess future climate change impacts on pastoral communities on the Italian Apennines chain. Specifically, a machine learning approach (Random Forest - RF), firstly calibrated for the present period and then applied to future conditions, as projected by HadCM3 General Circulation Model (GCM), was used to simulate potential expansion/reduction and/or altitudinal shifts of the Apennine pasturelands in two time slices, centred on 2050 and 2080, under A2 and B2 SRES scenarios. RF classification model proved to be robust and very efficient to predict lands suited to pastures with regards to present period (classification error: 12%). Furthermore, according to RF simulations, relevant reductions (46 and 34%) of areas potentially suitable for pastoral resource are expected under A2 at the middle and end of the century, respectively, as depicted by the GCM and SRES scenarios. Moreover, progressive upwards shifts are predicted by the model under both SRES scenarios. These reductions will likely interest the central area of the chain threatening the typical and unique herbaceous biodiversity characterizing the Apennine pasturelands.

**CLIMSAVE interactive platform for climate change impacts in Europe**

*Eric Audsley (Cranfield University)*

Describe the CLIMSAVE Integrated Assessment Platform showing the scope of models, inputs and outputs available. Present the results from applying theIAP for the six scenarios on the regional case study regions.Describe thenew aims of the follow-on IMPRESSIONS project.

**Self-similarity analysis of chosen agro-meteorological time series**

*Piotr Baranowski (Institute of Agrophysics of the Polish Academy of Sciences)*; *Jaromir Krzyszczak (Institute of Agrophysics of the Polish Academy of Sciences)*; *Cezary Sławiński (Institute of Agrophysics of the Polish Academy of Sciences)*

The most usual records of observable agro-meteorological quantities are in the form of time series and the knowledge about their scaling properties is fundamental for transferring locally measured fluctuations to larger scales and vice-versa. However, the scaling analysis of these quantities is complicated because of the presence of localized trends and nonstationarities. The objective of this study was to characterize scaling properties (i.e. statistical self-similarity) of the chosen agro-meteorological quantities through multifractal detrended fluctuation analysis (MFDFA). The MDFA analysis was performed for time series of the air temperature, wind velocity and relative air humidity (at the height of 2 m above the active surface) as well as the soil temperature (at 10 cm depth in the soil). The studied data were hourly interval, 12 years' time series from the agro-meteorological station in Felin, near Lublin, Poland. The empirical singularity spectra indicated their multifractal structure. The richness of the studied multifractals was evaluated by the width of their spectrum, indicating their considerable differences in dynamics and development. The log-log plots of the cumulative distributions of all the studied absolute and normalized meteorological parameters tended to linear functions for high values of the response indicating that these distributions were consistent with the power law asymptotic behaviour. Additionally, we investigated the type of multifractality, that underlies the q-dependence of the generalized Hurst exponent, by analyzing the corresponding shuffled and surrogate time series. For majority of studied quantities, the multifractality was due to different long-range correlation for small and large fluctuations.

**Comparing visions for CAP reforms post 2015: Farmer intentions and farm bio-economic modelling**

*Andrew Barnes (SRUC)*; *Shailesh Shrestha (SRUC)*; *Steven Thomson (SRUC)*; *Luiza Toma (SRUC)*; *Keith Mathews (James Hutton Institute)*; *Lee Ann Sutherland (James Hutton Institute)*

This paper illustrates the impacts of two of the potential CAP reform post 2015 scenarios using an optimising farm level model and compares results with farmers' perception about the policy changes, captured in a farmer intentions survey. The model results suggest that beef farms suffer a loss in farm net margins under fully decoupled (up to -21%) as well as under partially decoupled scenario (up to -19%) compared to current historical single farm payments. The model also shows that farm respond by reducing the number of beef animals on farm by up to 5%. However, under a partial decoupled scenario, beef farms increase calf numbers by 15% to benefit from coupled calf payment. A survey of 1,400 beef producers with respect to their intentions toward 2020 was conducted in the Summer of 2013. A set of hypothetical payment scenarios was used to test self-reported response to a number of scenarios related to expanding and extensifying. These were compared with the modelling results and found a range of responses which could, we argue, be used for future calibration and 'sense-checking' of results within future modelling strategies.

**Do modellers dream of electric sheep? – Practical to mathematical and back again.**

*Dave Bartley (Moredun Research Institute)*

Disease agents, whether viral, bacterial or parasitic, infecting grazing domestic animals represent a significant threat to livestock health and welfare and to food security, globally. In addition, inefficiency in production due to sub-clinical disease adds significantly to a farm's environmental footprint. Projected climatic changes over the short-medium term have implications for livestock pests and pathogens, both directly and indirectly, and will result in changing disease patterns e.g. incidence, seasonality and geographic spread. An area where interdisciplinary collaboration is mutually beneficial, and essential in order to gain a better understanding of the interactions between climatic change, pathogen dissemination and livestock productivity is between 'fundamental' or 'practical' livestock researchers and modellers. To facilitate this collaboration, there needs to be a dialogue between both parties on the data depth, quality and format required to populate different models to ensure relevant and appropriate outputs.

An example of where this type of collaboration has been used is work using an Intergovernmental Panel on Climate Change (IPCC)-compliant model (CPLANv2) to calculate greenhouse gases (GHG) associated with fattening lambs over five consecutive grazing seasons. The results demonstrated that effective control of sub-clinical/clinical parasitic gastroenteritis resulted in a ~10% reduction in GHG emissions/kg live weight gain (Kenyon et al., 2013).

**Deliberative processes for comprehensive evaluation of agro-ecological models**

*Gianni Bellocchi (French National Institute for Agricultural Research, Clermont-Ferrand)*; *Mike Rivington (The James Hutton Institute, Aberdeen)*; *Marco Acutis (University of Milan)*

Biophysical models are acknowledged for examining interactions of agro-ecological systems and fostering communication between scientists, managers and the public. As the role of models grows in importance, there is an increase in the need to assess their quality and performance (Bellocchi et al., 2010). However, the heterogeneity of factors influencing model outputs makes it difficult a full assessment of model features. Where models are used with or for stakeholders then model credibility depends not only on the outcomes of well-structured statistical evaluation but also less tangible factors may need to be addressed using complementary deliberative processes. To expand our horizons in the evaluation of crop and grassland models, approaches have been reviewed with emphasis on using combined metrics. Comprehensive evaluation of simulation models was developed to integrate expectations of stakeholders via a weighting system where lower and upper fuzzy bounds are applied to a set of evaluation metrics. A questionnaire-based survey helped understanding the multi-faceted knowledge and experience required and the substantial challenges posed by the deliberative process. MACSUR knowledge hub holds potential to advance in good modelling practice in relation with model evaluation (including access to appropriate software tools), an activity which is frequently neglected in the context of time-limited projects.

**Vul'Clim – Climate change vulnerability studies in the region Auvergne (France)**

*Gianni Bellocchi*; *Raphaël Martin (French National Institute for Agricultural Research,Clermont-Ferrand)*; *Anastasiya Shtiliyanova (French National Institute for Agricultural Research,Clermont-Ferrand)*; *Haythem Ben Touhami (French National Institute for Agricultural Research, Clermont-Ferrand)*; *Pascal Carrère (French National Institute for Agricultural Research,Clermont-Ferrand)*

The region Auvergne (France) is a major livestock territory in Europe (beef and dairy cattle with permanent grasslands), with a place in climate change regional studies assisting policy makers and actors in identifying adaptation and mitigation measures. Vul'Clim is a research grant (*Bourse Recherche Filière*) of the region Auvergne (February 2014-September 2015) to develop model-based vulnerability analysis approaches for a detailed assessment of climate change impacts at regional scale. Its main goal is the creation of a computer-aided platform for vulnerability assessment of grasslands, in interaction with stakeholders from a cluster of eco-enterprises. A modelling engine provided by the mechanistic, biogeochemical model PaSim (Pasture Simulation model) is the core of the platform. An action studies the changes of scales by varying the granularity of the data available at a given scale (e.g. climate data supplied by global scenarios) to let them being exploited at another scale (e.g. high-resolution pixels). Another action is to develop an assessment framework linking modelling tools to entry data and outputs, including a variety of components: data-entry manager at different spatial resolutions; automatic computation of indicators; gap-filling and data quality check; simulation kernel with the model(s) used; device to represent results as maps and integrated indicators.

**The development of cereals and oilseed production until 2050 under different socioeconomic conditions in Finland**

*Anne Biewald (Potsdam Institute of Climate Impact Research (PIK))*

We will use Finland as an example of a small, developed country with difficult climatic conditions to show how changes in global food consumption patterns and global population growth will influence local production. In order to do so we use two different models. First, an agricultural sector model for Finland, and second, a regionally adapted version of a global, spatially explicit agroeconomic land use model. We use both models to investigate how Finnish cereals and oilseed production develops under different socioeconomic conditions, as defined in the Socioeconomic Pathways (SSPs). We find that without a major improvement of oilseed yields, oilseed production will be disrupted by 2050 and even with a major increase in oilseeds yields only in the SSP2 scenario production of oilseeds can be sustained. Cereal production on the other hand does not change in the simulations with the global model, but does almost decrease by half in the simulations with the national model. This shows that even with an enormous global population growth and reduced international trade, Finland will not become a major agricultural producer.

**Simulating the sensitivity of carbon and water fluxes as well as yield within the ClimAfrica project**

*Per Bodin (Department of Physical Geography and Ecosystem Science, Lund University)*

Sub Saharan Africa (SSA) is a region expected to be particularly sensitive to climate change effects on crop yield (Barrios et al. 2008). Annual precipitation, calculated as averages for each African country, is expected to change by −39 to +64 mm by 2030 (Jarvis et al. 2012). The effect of climate also becomes larger as ~97 % of all agricultural land in SSA is rain fed (Rockström et al. 2004).

The aim of the ClimAfrica project (FP7) is to better understand and predict climate change in SSA and to analyse the impacts on ecosystems and populations. Within the modeling Work Package (WP3) the main goal is to quantify the sensitivity of vegetation productivity and water resources to seasonal interannual decadal variability in weather and climate using a set of crop models.

Here we present some results on the sensitivity of simulated carbon fluxes and FAPAR for different representations of cropland in a vegetation model (LPJ-GUESS: Lindeskog et al. 2013) as well as the sensitivity on simulated fluxes of carbon water and crop yield using a range of vegetation and crop

models (LPJ-GUESS, LPJmL, ORCHIDEE and DSSAT), climate datasets, GCM output and bias correction/downscaling techniques.

**"Methods of management with processes and resources in organizations and the economy" ,"Application of water saving irrigation and fertigation systems in plants cultivation"**

*Waldemar Bojar (University of Technology and Life Sciences)*; *Jacek Zarski (University of Technology and Life Sciences)*

The first research project concerns methods of management with processes and resources in organizations and the economy. In order to address socio-economic problems, methods for evaluating the way in which natural resources are globally utilised in the face of the adverse effects of climate change must be developed. Previous findings of the project MACSUR allow to formulate the hypothesis that the method developed in UTP integrated with models of MACSUR partners is useful to assess the impact of climate change on food security in the context of growing economic risks in agricultural production. Verified hypothesis allows us to expect a common understanding on the assessment of the impact of climate change on food security in the light of the growing threat of food production. The second research project is to assess the feasibility and effectiveness of the system of drip irrigation in the cultivation of selected crops in the area of particularly large water shortages . Field studies are carried out in parallel on two soil types in the Research Centre of the University of Technology and Life Sciences near Bydgoszcz. The results confirm the possibility of a significant increase in productivity of irrigated plants on very light and light soils. The most important result of the synergistic relationship of this project to MACSUR project can be economic evaluation of the cost-effectiveness of surveyed plants under conditions of increasing drought probability. The results will be presented to stakeholders - agricultural producers , which will confront their usefulness in the management of farms.

**A computable general equilibrium assessment of Spain's greenhouse gas emissions policies and abatement options**

*Michael Bourne (Centro de Investigación y Tecnología Agroalimentaria (CITA), Zaragoza, Spain.)*; *George Philippidis (European Comission Joint Research Centre, Seville, Spain.)*

Employing a recursive dynamic computable general equilibrium (CGE) model of the Spanish economy, this study aims to characterise the potential impact of Kyoto and European Union environmental policy targets on the Spanish economy up to 2020, with a focus on the agricultural sector. The model code is modified to characterise the emissions trading scheme (ETS), emissions quotas and carbon taxes, whilst emissions reductions are applied to all six registered greenhouse gases (GHGs). As extensions to this work, the study attempts to integrate the use of 'Marginal Abatement Cost' (MAC) curves for emissions reductions within the agricultural sector, and econometric estimates of the effects of global warming on land productivity in Spain.

**TradeM planning session of pilot studies**

*Floor Brouwer (Wageningen UR)*; *Franz Sinabell (WIFO)*

TradeM will organise a session to plan for the three regional pilot studies. Focus will be on the expected outcomes until early 2015 (e.g. progress in farm modelling, andother scientific advancements – uncertainty, model integration). In addition to the planning of the regional pilot studies for the remaining year in MACSUR, we will also elaborate proposals for the years 2015-2017. Moreover, the session will enable research groups to present and discuss their plans for cross-theme investigations.

**Land use dynamics and the environment**

*Carmen Camacho (CNRS, Universite Paris 1 Pantheon-Sorbonne ); Agustin Perez-Barahona (Institut National de la Recherche Agronomique (INRA))*

This paper builds a benchmark framework to study optimal land use, encompassing land use activities and environmental degradation. We focus on the spatial externalities of land use as drivers of spatial patterns: land is immobile by nature, but location's actions affect the whole space since pollution flows across locations resulting in both local and global damages. We prove that the decision maker problem has a solution, and characterize the corresponding social optimum trajectories by means of the Pontryagin conditions. We also show that the existence and uniqueness of steady-state solutions are not straightforward. Finally, a global dynamic algorithm is proposed in order to illustrate the spatial-dynamic richness of the model. We find that our simple set-up already reproduces a great variety of spatial patterns related to the interaction between land use activities and the environment. In particular, abatement technology turns out to play a central role as pollution stabilizer, allowing the economy to achieve stable steady-states that are spatially heterogeneous.

**Meteorological risks as drivers of environmental innovation in agro-ecosystem management**

*Yannick Curnel (Walloon Agricultural research centre (CRA-W), Farming systems, terrirories and information technology Unit)*

The extreme weather events, projected to increase both in frequency and magnitude with climate change have significant impact on agro-ecosystem services and pose severe limitations to sustainable agricultural land management. The proposed activities start from the hypothesis that these meteorological risks act as drivers of environmental innovation in agro-ecosystem management. These activities deal with risks associated with extreme weather phenomena and with risks of biological origin (e.g. pests and diseases). In order to reach this objective, the following elements of the chain of risk should be considered: • Hazard (assessment of the likely frequency and magnitude of extreme meteorological events) • Impact (analysis of the potential bio-physical and socio-economic impact of extreme weather events on agro-ecosystems) • Vulnerability (identification of the most vulnerable agro-ecosystems) • Risk Management (uncovering innovative risk management and adaptation options) These activities will concentrate on promoting a robust and flexible framework by demonstrating its performance across Belgian agro-ecosystems, and by ensuring its relevance to policy makers and practitioners. Impacts developed from physically based models will not only provide information on the state of the damage at any given time, but also assist in understanding the links between different factors causing damage and determining bio-physical vulnerability. Socio-economic impacts will enlarge the basis for vulnerability mapping, risk management and adaptation options. A strong expert and end-user network will be established to help exploiting project results to meet user needs

**Assessing water and energy footprint of irrigated agriculture in the Mediterranean**

*André Daccache (Cranfield University)*

Agriculture in the Mediterranean, one of the water scarcest regions in the world is by far the largest water consuming sector. Dwindling water supply, increase in drought frequency and uncertainties associated with climate change have raised the alerts on the region's food security and environmental sustainability. In this study, a large geo-database of global climate, soil and crop were combined with national irrigation statistics to run a water balance model to estimate the theoretical irrigation volumetric needs of the Mediterranean main strategic crops and their relative $CO_2$ emissions. When

associated with the reported crop yield and water resources availability, the spatial variability of water ($m^3$/kg) and energy ($CO_2$/kg) productivity across the Mediterranean region are obtained and vulnerable areas are identified. The estimated total water needs for the Mediterranean irrigated agriculture under current climate, land cover and irrigation methods was estimated to be around 46$km^3$/year releasing more than 3Mt of $CO_2$ in the atmosphere only from water abstraction and farm application. Currently, 59% of total irrigation water needs are located in catchments that are classified as under high and extremely high water risk. With climate change, water resources are expected to become scarcer and agriculture more dependent on irrigation to satisfy the continuous increase in food demand. Adaptation and mitigation options to tackle water scarcity and improve productivity under current and future climate will be discussed.

**LiveM WP4: Methods for regional scale farming systems modelling and uncertainty assessment – sustainability assessment case studies of production, nutrient losses and greenhouse gas emissions from grassland based systems**

*Tommy Dalgaard (Aarhus University)*

In the EU Joint-Programming-Initiative: Modelling European Agriculturewith Climate Change for Food Security (MACSUR, LiveM: http://www.macsur.eu/index.php/livestock-modelling) we develop a research frameworkfor the modelling and sustainability assessment of livestock and grasslandbased farming systems at farm and regional scales.Based on results from related research and model development in Denmark,methodologies used for regional scaling, the description of data requirementsand sources, and methods to predict the effect and effectiveness of climate-and environment related policy measures are developed. In this study we present results from farm modelling in a study areaaround Viborg, Western Denmark using the http://www.Farm-N.dk/ model (Env.Pol. 159 3183-3192), including thedistribution of N-surpluses into different types of losses, and a comparisonwith empirical studies of farm nitrogen balances in the Danish study and fiveadditional European landscapes (Biogeosciences 9, 5303–5321). Based on this,methods and development needs for the mapping and uncertainty assessment ofnutrient losses and greenhouse gas emissions are discussed, referring to the presentdevelopment of the Farm-AC model and ongoing scenario studies in e.g. the www.dNmark.org project. In these scenarios, regional-scale policy measures areimplemented via the responses of a range of stakeholders, such as farmers,public interest groups, regulators and politicians. When modelling the outcomeof the policy measures implementation, it is often assumed that stakeholdersrespond as economically rational entities. However, social and cultural factorsare also known to play a role and modelling methods that permit these factorsto be taken into account will also be discussed.

**Methods for regional scale farming systems modelling and uncertainty assessment – sustainability assessment case studies of production, nutrient losses and greenhouse gas emissions from grassland based systems**

*Tommy Dalgaard (Aarhus University, Dept. Agroecololgy)*; *Nick Hutchings (Aarhus University, Dept. Agroecololgy)*; *Egon Noe (Aarhus University, Dept. Agroecololgy)*

In the EU Joint-Programming-Initiative: Modelling European Agriculturewith Climate Change for Food Security (MACSUR, LiveM: http://www.macsur.eu/index.php/livestock-modelling) we develop a research frameworkfor the modelling and sustainability assessment of livestock and grasslandbased farming systems at farm and regional scales.Based on results from related research and model development in Denmark,methodologies used for regional scaling, the description of data requirementsand sources, and methods to predict the effect and effectiveness of climate-and environment related policy measures are developed. In this study we present results from farm modelling in a study areaaround Viborg, Western

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**Filtering methods for predicting and modelling wheat yield in the context of climate change**

*Marie-France Destain (University of Liège)*

In this paper, an Improved Particle Filtering (IPF) based on minimizing Kullback-Leibler divergence will be proposed for biomass prediction of a wheat crop model in the context of climate change including heat and drought stresses.

In a first stage, the performances of the proposed technique will be compared with those of the extended Kalman filter (EKF), unscented Kalman filter (UKF), Particle filter (PF). In a second stage, the state estimation techniques EKF, UKF, PF and IPF will be used for updating prediction of the model in order to predict winter wheat biomass, in specific field conditions, during several contrasted weather conditions. In a third stage, the effects of practical challenges on the performances of the state estimation algorithms will be assessed. Such practical challenges include the effect of measurement noise on the estimation performances and the measurement frequency of state variables.

The first results show that the UKF provides a higher accuracy than the EKF due to the limited ability of EKF to accurately estimate the mean and covariance matrix of the estimated states through lineralization of the nonlinear process model. The results also show that the IPF provides a significant improvement over PF because, unlike the PF which depends on the choice of sampling distribution used to estimate the posterior distribution, the IPF yields an optimum choice of the sampling distribution, which also accounts for the observed data. For all techniques, the practical challenges affect the estimation accuracy as well as the convergence of the estimated states and parameters. However, the IPF can still provide both convergence as well as accuracy over other estimation methods. These advantages are precious in presence of high climate stresses.

**The adaptation of farm and awareness of ongoing climate change (CC)**

*Gabriele Dono (Università degli studi della Tuscia)*; *Raffaele Cortignani (Università degli studi della Tuscia)*; *Luca Doro (Università degli studi di Sassari)*; *Pier Paolo Roggero (Università degli studi di Sassari)*

Farm planning is based on awareness of climate variability, here assumed to depend on experience gained over the years, and to generate expectations on climatic variables. Expectations are based on probability distributions (pdfs) estimated on climate data and used to generate managing choices by means of Discrete Stochastic Programming. The model simulates the income losses in case farmers do not recognize the ongoing CC, and continue to plan assuming climate stability. In particular, the use of resources in 2010 is simulated based on the pdfs of the early 2000s, despite CC has changed the probabilities of the various states of nature. The model, calibrated with Positive Mathematical Programming, generates a 0.9% income increase when is allowed to adapt to 2010 climate pdfs. The

model is also calibrated according to pdfs of 2010, i.e. recognizing CC: in this case income falls of 0.7% when farmers are simulated to use their soil mistakenly based of the 2000 pdfs. Given the short period of CC, the differences represent an appreciable error that farmers may be already committing. Properly specifying with the CC at local level can help building farmers' awareness on it, and to properly manage their resources, recovering profitability.

**MACSUR CropM – progress overview**

*Frank Ewert (Institute of Crop Science and Resource Conservation (INRES), University of Bonn)*; *Reimund Rötter (MTT Finland)*

Activities in the first 1 ½ years of CropM were related to key issues identified as critical at the beginning of the FACCE MACSUR the knowledge Hub. These include:

- Model intercomparison
- Generation of new data for model improvement
- Methods for scaling and model linking
- Uncertainty analysis
- Building research capacity
- Climate scenario data for crop models

The key ambition of CropM has been to develop scientific excellence on methods for a comprehensive assessment of climate change impact, adaptation and policy on European crop production, agriculture and food security. Much progress has been made in developing a first shared continental assessment and tool for:

- A range of important crops
- Important crop rotations
- Advanced scaling methods
- Advanced link to farm and sector models
- Novel impact uncertainty assessment and reporting
- State-of-the-art scenario construction

A number of concrete studies towards this aim have been launched in CropM workpackages (WPs):

- WP1-2: Two multi-facetted studies on crop rotation, launched in summer 2013
- WP3: comprehensive scaling exercises, launched in March 2013
- WP4: Studies on (a) Climate scenario development, (b) impact response surface method and (c) Extremes, launched in summer 2013
- WP5: Analysis of transect across Europe with temperature effect (Space for Time)

In addition, extended activities related to capacity building including several PhD courses (WP5) workshops (in WPs1-4) and an International Symposium (10-12 Feb, Oslo, Norway) have been organized. Present and future work is and will be focused on framing and advancing crop modelling as integrated part of comprehensive climate risk assessment and modelling of agricultural systems for food security from farm to supra-national level.

**Within-season predictions of durum wheat yield over the Mediterranean Basin**

*Roberto Ferrise (Dep. of Agri-food Production and Environmental Sciences (DISPAA), University of Florence, IT)*; *Marco Moriondo (Institute of Biometeorology (IBIMET), CNR Firenze, IT)*; *Massimiliano Pasqui (Institute of Biometeorology (IBIMET), CNR Roma, IT)*; *Jacopo Primicerio (Institute of Biometeorology (IBIMET), CNR Roma, IT)*; *Piero Toscano (Institute of Biometeorology (IBIMET), CNR Firenze, IT)*; *Mikhail Semenov (Computational and System Biology Dep., Rothamsted Research,*

*Harpenden, Herts, AL5 2JQ, UK)*; *Marco Bindi (Dep. of Agri-food Production and Environmental Sciences (DISPAA), University of Florence, IT)*

Crop yield is the result of the interactions between weather in the incoming season and how farmers decide to manage and protect their crops. According to Jones et al. (2000), uncertainties in the weather of the forthcoming season leads farmers to lose some productivity by taking management decisions based on their own experience of the climate or by adopting conservative strategies aimed at reducing the risks. Accordingly, predicting crop yield in advance, in response to different managements, environments and weathers would assist farm-management decisions(Lawless and Semenov, 2005).

Following the approach described by Semenov and Doblas-Reyes (2007), this study aimed at assessing the utility of different seasonal forecasting methodologies in predicting durum wheat yield at 10 different sites across the Mediterranean Basin. The crop model, SiriusQuality (Martre et al., 2006), was used to compute wheat yield over a 10-years period. First, the model was run with a set of observed weather data to calculate the reference yield distributions. Then, starting from 1$^{st}$ January, yield predictions were produced at a monthly time-step using seasonal forecasts. The results were compared with the reference yields to assess the efficacy of the forecasting methodologies to estimate within-season yields.

The results indicate that durum wheat phenology and yield can be accurately predicted under Mediterranean conditions well before crop maturity, although some differences between the sites and the forecasting methodologies were revealed. Useful information can be thus provided for helping farmers to reduce negative impacts or take advantage from favorable conditions.

**Implementing agricultural land-use in the CARAIB dynamic vegetation model**

*Louis François (University of Liège)*; *Ingrid Jacquemin (<pre>University of Liège</pre>)*; *Corentin Fontaine (University of Namur)*; *Julien Minet (University of Liège)*; *Marie Dury (University of Liège)*; *Bernard Tychon (University of Liège)*

CARAIB (Dury et al., 2011) is a state-of-the-art dynamic vegetation model with various modules dealing with (i) soil hydrology, (ii) photosynthesis/stomatal regulation, (iii) carbon allocation and biomass growth, (iv) litter/soil carbon dynamics, (v) vegetation cover dynamics, (vi) seed dispersal, and (vii) vegetation fires. Climate and atmospheric $CO_2$ are the primary inputs. The model calculates all major water and $CO_2$/carbon fluxes and pools. It can be run with plant functional types or species (up to 100 different species) at various spatial scales, from the municipality to country or continental levels.

Within the VOTES project (Fontaine et al., 2013), the model has been improved to include crops and meadows, and some modules have been written to translate model outputs into quantitative indicators of ecosystem services (e.g., evaluate crop yield from net primary productivity or calculate soil erosion from runoff, slope, grown species and various soil attributes). The model was run over an area covering four municipalities in central Belgium, where land-use is dominated by crops, meadows, housing and some forests and was introduced in the model at the land parcel level. Simulations were also performed for the future. In these simulations, CARAIB was combined with the Aporia Agent-Based Model, to project land-use changes up to 2050. This approach is currently extended within the MASC project (funded by Belgian Science Policy, BELSPO) to the whole Belgian territory (at 1 km$^2$) and to Western Europe (at 20 km x 20 km).

**Projected climate change impact on wheat and maize in Italy**

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Agriculture is one of the most important sectors for global economy. Its high vulnerability to climate conditions cause a serious concern for the consequence determined by the incoming climate changes. The increase in temperature and decrease in rainfall, projected for the next decades in the Mediterranean Basin, may cause a significant impact on crop development and production.

In this contest, the assessment of the climate change impacts on crop growth and yield is necessary in order to identify the crops and areas more vulnerable and suggest adaptation strategies to cope with climate change.

The use of crop simulation models, such as those implemented in DSSAT-CSM (Decision Support System for Agrotechnology Transfer - Cropping System Model) software, version 4.5., is the most common approach for the assessment of climate change impacts on crop development and yields. These models are often used at field scale. However, recent studies have been carried out at both regional and continental scale.

In this work, CSM-CERES-Wheat and CSM-CERES-Maize crop models, parameterized at Italian scale for different varieties of durum wheat, common wheat and maize, were applied to assess climate change impacts on crop phenology and productivity. Dynamically downscaled climate data, using by the Regional Climate Model COSMO-CLM, and RCP 4.5 and 8.5 scenarios were used for impact assessment. Moreover, some adaptation strategies were evaluated. Results, analyzed at regional level, will be discussed.

**Comparison of measured and modelled soil organic carbon for a northern European long-term experiment site**

*Balázs Grosz (Johann Heinrich von Thünen Institute (vTI) Thünen Institute of Climate-Smart Agriculture)*; *Rene Dechow (Johann Heinrich von Thünen Institute (vTI) Thünen Institute of Climate-Smart Agriculture)*; *Rene Dechow (Johann Heinrich von Thünen Institute (vTI) Thünen Institute of Climate-Smart Agriculture)*

Soil organic carbon is a key variable with regard to soil fertility influencing yield and yield security of agricultural crop production by regulating water budget and nutrient cycling. Those services might become even more relevant with respect to climate change. The sensitivity of crop yields on soil organic carbon content is influenced by site-specific conditions. To assess future vulnerability of yield security with respect to soil organic carbon contents in European croplands soil-crop models must consider the interaction of SOC and crop growth. Long term experiments that include treatments which lead to variable soil organic carbon contents can provide information on those relationships. Because the effect of soil fertility functions supported by SOC depends on a range of natural and anthropogenic factors we used various long term experiments in Sweden and Germany to evaluate the model CENTURY4.6. Thereafter we examined the impact of SOC on crop yields on site level by scenario runs modifying initial SOC levels and weather conditions. Preliminary results show differences in the modeled and observed soil organic carbon values for a range of observed long term experiments. The difference between modelled and measured of SOC stocks is up to 30% after 56 years. Overall, The use of the default values

and setting were not appropriate to derive acceptable results, so the adjustment of some model parameter are required.

**Parameter-induced uncertainty quantification of a regional N2O and NO3 inventory using the biogeochemical model LandscapeDNDC**

*Edwin Haas (Karlsruhe Institute of Technology (KIT))*; *Steffen Klatt (Karlsruhe Institute of Technology (KIT))*; *Ralf Kiese (Karlsruhe Institute of Technology (KIT))*; *Ignacio Santa Barbara Ruiz (Karlsruhe Institute of Technology (KIT))*; *David Kraus (Karlsruhe Institute of Technology (KIT))*

In this study we quantify regional parameter-induced model uncertainty on nitrous oxide (N2O) emissions and nitrate (NO3) leaching from arable soils of Saxony (Germany) using the biogeochemical model LandscapeDNDC. For this we calculate a regional inventory using a joint parameter distribution for key parameters describing microbial C and N turnover processes as obtained by a Bayesian calibration study. We representatively sampled 400 different parameter vectors from the discrete joint parameter distribution comprising approximately 400,000 parameter combinations and used these to calculate 400 individual realizations of the regional inventory. The spatial domain (represented by 4042 polygons) is set up with spatially explicit soil and climate information and a region-typical 3-year crop rotation consisting of winter wheat, rape- seed, and winter barley.

Average N2O emission from arable soils in the state of Saxony across all 400 realizations was 1.43 ± 1.25 [kg N / ha] with a median value of 1.05 [kg N / ha]. Using the default IPCC emission factor approach (Tier 1) for direct emissions reveal a higher average N2O emission of 1.51 [kg N / ha] due to fertilizer use. In the regional uncertainty quantification the 20% likelihood range for N2O emissions is 0.79 – 1.37 [kg N / ha] (50% likelihood: 0.46 – 2.05 [kg N / ha]; 90% likelihood: 0.11 – 4.03 [kg N / ha]). Respective quantities were calculated for nitrate leaching.

**Effects of climate change on feed availability and the implications for the livestock sector**

*Petr Havlik (Ecosystems Services and Management Program, International Institute for Applied Systems Analysis (IIASA), Laxenburg)*; *David Leclere (International Institute for Applied Systems Analysis)*; *Hugo Valin (International Institute for Applied Systems Analysis)*; *Mario Herrero (Commonwealth Scientific and Industrial Research Organisation)*; *Erwin Schmid (University of Natural Resources and Life Sciences)*; *Michael Obersteiner (International Institute for Applied Systems Analysis)*

Global mean surface temperature is projected to rise by 0.4-2.6°C until 2050, and the contrast in precipitations between wet and dry regions and wet and dry seasons will also increase according to the IPCC 5$^{th}$ Assessment Report (2013). The climate change will impact livestock in many ways going from heat stress through livestock diseases to feed quality and availability (Thornton *et al.*, 2009). Recently, projected climate change impacts on crop and grassland productivity became available with high spatial resolution at global scale through the AgMIP and ISI-MIP projects. The objective of this paper is to investigate how climate change impacts on crops and grassland will influence livestock production globally and its distribution across regions.

This analysis is carried out using the global partial equilibrium agricultural and forestry sector model GLOBIOM (Havlík *et al.*, 2013). The model represents agricultural production at a spatial resolution going down to 5 x 5 minutes of arc. Crop and grassland productivities are estimated by means of biophysical process based models (EPIC and CENTURY) at this resolution for current and future climate. Livestock representation follows a simplified version of the Seré and Steinfeld (1996) production system classification. This approach recognizes differences in feed base and productivities between grazing and

mixed crop-livestock production systems across different agro-ecological zones (arid, humid, temperate/highlands).

Our study highlights that the differential impacts of climate change on crop and grassland productivity will influence the relative competitiveness of different livestock production systems. Maintaining livestock production in some regions will depend on their capacity to adapt. Institutional and physical infrastructure will be needed to facilitate these transformations.

**Policy impact assessment – a venue for the science policy interface**

*Katharina Helming (ZALF)*; *Aranka Podhora (ZALF)*; *Hannes König (ZALF)*

Policy making aims to align agricultural production with multifunctional services such as environmental conservation, rural development, and economic competitiveness. Policies counteract or reinforce external driving forces such as climate change, global economic developments, demography, consumption patterns. They considerably affect decision making of farmers. Because of the interaction and non-linear feedback loops with socio-economic and geophysical processes of the land use systems, policies are difficult to design, and their impacts are difficult to anticipate.

The policy making community articulates an emerging demand for science based evidence in support of the policy process. Ex-ante impact assessment of policy making provides the legal basis to fuel scientific evidence into the policy process. For researchers, impact assessment is a means to structure the analysis of human-environment interactions. For policy makers, impact assessment is a means to better target policy decisions towards sustainable development. The integration of both requires a mutual understanding of the respective objectives and operational restrictions within the scientific and policy-making domains.

This paper provides insight into the process of policy impact assessment and how research based methods and tools can best feed into it. Three aspects are outlined: the co-design of the assessment between policy makers and researchers; the integration of quantitative analysis with participatory valuation methods; and the robustness and transparency of the analytical methods.

**LIAISE – Linking Impact Assessment instruments with sustainability expertise**

*Katharina Helming (ZALF)*; *Sander Janssen (Wageningen UR)*

Impact Assessment for Sustainable Development: Knowledge Systems for the Future

The ex ante Impact Asssessment of planned policies has developed as an important part of policy making within the European institutions as well as in Member States. The analysis of expected economic, social and environmental impacts informs the decision making. **Collecting relevant and trustworthy evidence is a challenge for policy decisions**. At the same time, **Impact Assessment is an opportunity for researchers, research organisations and funding agencies** to develop knowledge relevant for societal decision making.

As a European research consortium LIAISE investigated over the past 4.5 years the Impact Assessment (IA) practices in relation to Sustainable Development (SD). Specific attention was given to the question **how the process of IA in various venues** (i.e. nation states, supra national organizations and local organizations) **is related to the processes of research and knowledge production**.

**Effects of climate input data aggregation on modelling regional crop yields**

*Holger Hoffmann (University of Bonn)*; *Gang Zhao*; *Lenny van Bussel*; *Andreas Enders*; *Xenia Specka*; *Carmen Sosa*; *Jagadeesh Yeluripati*; *Fulu Tao*; *Julie Constantin*; *Edmar Teixeira*; *Balasz Grosz*; *Luca Doro*; *Claas Nendel*; *Ralf Kiese*; *Helene Raynal*; *Henrik Eckersten*; *Edwin Haas*; *Matthias Kuhnert*; *Elisabet Lewan*; *Michaela Bach*; *Kurt-Christian Kersebaum*; *Pier Roggero*; *Reimund Rötter*; *Daniel Wallach*; *Gunther Krauss*; *Stefan Siebert*; *Thomas Gaiser*; *Enli Wang*; *Zhigan Zhao*; *Frank Ewert*

Crop models can be sensitive to climate input data aggregation and this response may differ among models. This should be considered when applying field-scale models for assessment of climate change impacts on larger spatial scales or when coupling models across scales.

In order to evaluate these effects systematically, an ensemble of ten crop models was run with climate input data on different spatial aggregations ranging from 1, 10, 25, 50 and 100 km horizontal resolution for the state of North Rhine-Westphalia, Germany. Models were minimally calibrated to typical sowing and harvest dates, and crop yields observed in the region, subsequently simulating potential, water-limited and nitrogen-limited production of winter wheat and silage maize for 1982-2011. Outputs were analysed for 19 variables (yield, evapotranspiration, soil organic carbon, etc.). In this study the sensitivity of the individual models and the model ensemble in response to input data aggregation is assessed for crop yield.

Results show that the mean yield of the region calculated from climate time series of 1 km horizontal resolution changes only little when using climate input data of higher aggregation levels for most models. However, yield frequency distributions change with aggregation, resembling observed data better with increasing resolution. With few exceptions, these results apply to the two crops and three production situations (potential, water-, nitrogen-limited) and across models including the model ensemble, regardless of differences among models in simulated yield levels and spatial yield patterns. Results of this study improve the confidence of using crop models at varying scales.

**Prototype stochastic general equilibrium model of a global food system**

*Øyvind Hoveid (Norwegian Agricultural Economics Research Institute (NILF))*

A model of a global food system need at least two points in time per year and two locations with different growing seasons so that planting and harvesting have different timing across locations. Moreover, planting decisions reflect soil states affected by stochastic weather since previous point in time, while harvest reflect the planting decisions and the stochastic weather through the growing season up to next point. Decisions on trade, storage and consumption are taken at every point in time. Despite stochastic influence, deterministic stationary general equilibrium is applicable. The world then runs in circles through a likely sequence of N given weather scenarios, while the decision-makers do not know the next scenario. The model will provide a setting in which the consequences of climate change can be assessed both with respect to expectations and variances. It will by construction be an integrated assessment model (IAM) in the sense that outcomes follow from agent choices in a world of biophysical processes. In this case the biophysical world is stochastic. At the prototype stage neither existing behavioral nor bio-physical models will be applied.

**Farm-scale modelling**

*Nicholas Hutchings*

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**Data format standards and variable mapping**

*Jason Jorgenson (University of Reading)*

Short report on work being done tools used for standardising data formats, including variable name mapping.

**Farm level approach to manage grass yield variation in changing climate in Jokioinen and St. Petersburg**

*Pellervo Kässi (MTT Agrifood Research Finland, Economic research, Latokartanonkaari 9, 00790 Helsinki, FINLAND)*; *Olli Niskanen (MTT Agrifood Research Finland, Economic research, Latokartanonkaari 9, 00790 Helsinki, FINLAND)*; *Hannu Känkänen (MTT Agrifood Research Finland, Plant production research, Tietotie, 31600 Jokioinen, FINLAND )*

Cattle's feeding is based on grass silage in Northern Europe, but grass growth is highly dependent on weather conditions. In farms decision making, grass area is usually determined by the variation of yield. To be adequate in every situation, the lowest expected yield level determines the cultivated area. Other way to manage the grass yield risk is to increase silage storage capacity over annual consumption. Variation of grass yield in climate data from years 1961-1990 was compared with 15 different climate scenario models simulating years 2046-2065. A model was developed for evaluating the inadequacy risk in terms of cultivated area and storing capacity. The cost of risk is presented and discussed.

In northern Europe a typical farm has storage for roughage consumption of almost one year. In addition, there can be a buffer storage. The extra storage is to be used before and during the harvest season. New harvest will be fed to animals only after the buffer empty. Shortage in the buffer storage is possible to be filled, when the yield exceeds the target level. For risk management, two alternative mechanisms are given: forage buffer and possibility to alter the field area.

According to our results, there are no significant adverse effects in the cost of risk and implied farm profitability due to climate change. Selecting the risk management scenario of 30 % grass yield risk turned out to be the least cost solution.

**The long-term trends in soil carbon stock and crop productivity depending on management in Estonia**

*Karin Kauer (Estonian University of Life Sciences)*; *Berit Tein (Estonian University of Life Sciences)*; *Evelin Loit (Estonian University of Life Sciences)*

The dynamics of soil organic carbon (SOC) content and crop productivity were studied on three still continuing field experiments situated at the experimental station of the Estonian University of Life Sciences in Tartu, Estonia.

The first trial was established in 1964. The effect of mineral fertilizers and farmyard manure applied to barley and sward with different species composition on soil organic carbon content was studied. The second trial with 3-crop rotation (potato - spring wheat - spring barley) was established in 1989. Experimental factors were organic (without amendment, solid cattle manure and alternative organic fertilisers) and mineral fertilisers (0, 40, 80, 120 and 160 kg N $ha^{-1}$). The third field experiment with 5-crop rotation experiment was established in 2008. Five different crops were following each other – barley undersown with red clover, red clover, winter wheat, pea and potato. Experimental factors were organic (catch crops as green manures, catch crops as green manures combined with composted cattle manure) and conventional farming systems. The conventional farming systems differed in the amounts of mineral fertilizers used: 0, 50, 100 and 150 kg N $ha^{-1}$.

The first goal of this research was to quantify plant C inputs to the soil in Estonian arable lands and the net primary production using crop-specific allometric relationships. Secondly, the impact of the different management scenarios on the changes in soil C stock was evaluated using plant C input data. The preliminary results of these data analysis will be presented.

**Model inter-comparison on crop rotation effects – an intermediate report**

*Kurt Christian Kersebaum (Leibniz-Zentrum für Agrarlandschaftsforschung (ZALF) e.V.)*; *Chris Kollas (Leibniz-Zentrum für Agrarlandschaftsforschung (ZALF) e.V.)*; *Marco Bindi (University of Florence)*; *Taru Palosuo (MTT Finland)*; *Lianhai Wu*; *Behzad Sharif*; *Isik Öztürk*; *Mirek Trnka*; *Petr Hlavinka*; *Claas Nendel*; *Christoph Müller*; *Katharina Waha*; *Cecilia Armas-Herrera*; *Jørgen Olesen*; *Josef Eitzinger*; *Pier Roggero*; *Tobias Conradt*; *Pierre Martre*; *Roberto Ferrise*; *Marco Moriondo*; *Margarita Ruiz-Ramos*; *Domenico Ventrella*; *Reimund Rötter*; *Martin Wegehenkel*; *Henrik Eckersten*; *Ignacio Lorite Torres*; *Carlos Hernandez*; *Marie Launay*; *Allard de Wit*; *Holger Hoffmann*; *Hans-Joachim Weigel*; *Remigius Manderscheid*; *Nicolas Beaudoin*; *Julie Constantin*; *Iñaki Garcia de Cortazar-Atauri*; *Bruno Mary*; *Dominique Ripoche*; *Françoise Ruget*

Data of diverse crop rotations from five locations across Europe were distributed to modelers to investigate the capability of models to handle complex crop rotations and management interactions. Crop rotations comprise various main crops (winter/spring wheat, winter/spring barley, rye, oat, maize, sugar beet, oil seed rape and potatoes) plus several catch crops. The experimental setup of the datasets included treatments such as modified soils, crops exchanged within the rotations, irrigation/rainfed, nitrogen fertilization, residue management, tillage and atmospheric $CO_2$ concentration. 19 modeling teams registered to model either the whole rotation or single crops. Models which are capable to run the whole rotation should provide transient as well as single year simulations with a reset of initial conditions. In the first step only initial soil conditions (water and soil mineral N) of the first year and key phenological stages were provided to the modelers. For calibration, crop yields and biomass were provided for selected years but not for all seasons. In total the combination of treatments and seasons results in 301 years of simulation.

Results were analyzed to evaluate the effect of transient simulation versus single-year simulation regarding crop yield, biomass, water and nitrogen balance components. Model results will be evaluated crop-specifically to identify crops with highest uncertainty and potential for model improvement. Full data will be provided to modelers for model-improvement and results will provide insights into model capabilities to reproduce treatments and crops. Further, the question of error propagation along the transient simulation of crop rotations will be addressed.

**Building modelling capacity for livestock systems: progress in LiveM**

*Richard Kipling (Aberystwyth University)*; *Eli Saetnan (Aberystwyth University)*; *Agnes van den Pol-van Dasselaar (Wageningen UR)*; *Nigel Scollan (Aberystwyth University)*

MACSUR provides an opportunity to connect disparate research groups and disciplines in livestock and grassland modelling. Within the livestock theme (LiveM) of MACSUR, grassland modelling capabilities have been significantly improved through joint modelling exercises, and grassland modellers have exploited their methodological overlaps with CropM to make important contributions to regional pilot studies. Animal health researchers have been contributing to the southern regional pilot, and modelling resources have been identified for livestock systems at the animal and farm-scales. Here, the priorities for the next steps for livestock and grassland modelling are discussed, and for the role of MACSUR in addressing the challenges facing the sector. While crop and grassland modelling deals with primary

production, livestock modelling examines the complexity of secondary production. The unique position of livestock modelling presents challenges and opportunities. The diversity of livestock models (in scale and approach) makes model inter-comparisons and collaborative work challenging, while the range of variables involved in livestock systems provide many opportunities for increasing systemic efficiency and robustness to the impacts of climate change. Closer integration of experimental research and modelling teams also has the potential to increase the capability of livestock and grassland models to predict the impact of European adaptation strategies on livestock farming systems, and on the contribution of these systems to global food security.

**Livestock production and the feed challenge**

*Richard Kipling (Aberystwyth University)*; *Nigel Scollan (Aberystwyth University)*

It is predicted that world population will reach nine billion by 2050 (Godfray et al., 2010) with the biggest increases occurring in the developing world (Guyomard et al., 2013, Thornton, 2010). This growth is expected to dramatically increase the demand for meat and animal products (Tilman et al., 2002) with a requirement by 2050 for 73 % more meat and 58 % more milk than produced in 2010 (FAO, 2011). In order to meet this growing demand, the supply of livestock products must rise to an extent comparable with that of the 'Green Revolution' (Tilman et al., 2002). This must occur in the context of serious global challenges related to climate change, resource availability, inequality, and biodiversity loss. At present many European livestock production systems are heavily reliant on a small number of feed products to provide protein, with imported soya accounting for 55 % of the 2.6 million tonnes of plant-derived protein fed to animals in the UK. This reliance on a small number of imported products leaves supply vulnerable to economic and climatic change. There is increased research into alternatives to South American soybean in the European feed supply chain, including improving the nutritional and agronomic characteristics of such alternatives, and exploring the use of new sources of potential feed material. This presents an opportunity for collaboration between experimental researchers and modellers to investigate the potential impacts of alternative feeds on livestock system productivity, robustness to climate change and levels of GHG emissions.

**Assessing the availability of data on grassland Carbon sequestration in Europe**

*Richard Kipling (Aberystwyth University)*; *Axel Don (Thünen-Institut (TI))*; *Kairsty Topp (SRUC)*

The role of grasslands in the sequestration of atmospheric Carbon represents an important benefit of extensive livestock systems based on permanent grasslands. The accurate modelling of such systems is key to understanding their potential in mitigating GHG emissions, and this in turn relies on access to high quality data. Here, the availability of Carbon sequestration data for EU grasslands is investigated, using information gathered from reviews of journal papers and EU project outputs. The challenges involved in providing information on datasets to modellers are discussed, and the next steps in the gathering and sharing of meta-data are defined.

**Responses of soil N2O emissions and nitrate leaching on climate input data aggregation: a biogeochemistry model ensemble study**

*Steffen Klatt (Karlsruhe Institute of Technology (KIT))*; *Edwin Haas (Karlsruhe Institute of Technology (KIT))*; *Ralf Kiese (Karlsruhe Institute of Technology (KIT))*

Models are increasingly used to estimate greenhouse gas emissions at site to regional and national scales and are outlined as the most advanced methodology for national emission reporting in the framework of

UNFCCC. Process-based models incorporate the major processes of the carbon and nitrogen cycle and are thus thought to be widely applicable at various spatial and temporal scales. The definition of the spatial scale is determined by the objectives. GHG emission reporting requests spatially and temporally aggregated information whereas for the assessment of mitigation options on hot spots and hot moments of emissions a high spatial simulation resolution is required. In addition, other input data also determine the simulation scale.

Low resolution simulations needs less effort in computation and data management, but important details could be lost during the process of data aggregation associated with high uncertainties of the simulation results. This study presents the aggregation effects of climate input data on the simulations of soil N2O emissions and nitrate leaching by comparing different biogeochemistry models. Using process-based models (DailyDayCent, LandscapeDNDC, Stics, Mode, Coup, Epic), we simulated a 30-year cropping system for two crops (winter wheat and maize monocultures) under water- and nutrient-limited conditions based on a 1 km resolution climate dataset. We aggregated the climate data to resolutions of 10, 25, 50, and 100 km and repeated the simulations on these spatial scales. We calculated the N2O emissions as well as the nitrate leaching on all scales. Results will be presented and discussed.

**General outline of plans for an extension phase of MACSUR**

*Martin Köchy (Thünen Institute)*; *Martin Banse*; *Richard Tiffin*; *Frank Ewert*; *Reimund Rötter*; *Agnes van den Pol-van Dasselaar*; *Floor Brouwer*; *Franz Sinabell*; *Jason Jorgenson*; *Elis Sætnan*; *Richard Kipling*

FACCE MACSUR has indicated a possible extension of funding by two years until May 2017 (phase 2).

For phase 2, hub and theme coordinators suggest the following main activities, that will be discussed during the remainder of the meeting and in the coming months.

- Evolution, upscaling, and transfer of knowledge gained in regional case studies.
- Assessment of additional scenarios of socio-economic and climate trends.
- Further development of an interdisciplinary scientific community.
- Extending scaling methods for crop models to the European and global scale.
- Intensification of feed quality and animal health modelling with climate change.
- Economic models from farm to global level capable of reflecting climate change.

**Effect of drought and heat stresses on transpiration and photosynthesis of wheat**

*Katarzyna Kondracka (Institute of Agrophysics of the Polish Academy of Sciences)*; *Artur Nosalewicz (Institute of Agrophysics of the Polish Academy of Sciences)*; *Jerzy Lipiec (Institute of Agrophysics of the Polish Academy of Sciences)*

Global warming and frequent extreme weather conditions affect crop yields worldwide. Drought and high temperatures are among stresses that often act simultaneously. Therefore the aim of the studies was to analyze effect of combined drought and heat stresses on growth and function of spring wheat.

The experiment was conducted in a growth chamber conditions. Spring wheat cv Łagwa was planted in soil columns of 10cm in diameter and 45cm high filled with Orthic Luvisol developed from loess and grown up to the end of flowering. The treatments were: (C) control with optimum growth soil water potential 160 hPa (pF 2.2) , 250 µmol $m^{-2}s^{-1}$ PAR, 22/18 °C day / night temperatures and 60% air relative humidity throughout growing period; (D) drought stress with soil water potential 250 kPa (pF 3.4) at flowering; (HT) high temperature stress with air temperature 34/24°C and optimum soil water potential ; (DHT) drought (as above) and high temperature (34/24°C day / night) stresses at flowering. During the

experiment photosynthesis rate, transpiration and stomatal conductance were measured using the gas exchange system GFS-3000 and DualPAM 100 (Walz, Germany).

Drought stress reduced photosynthesis rate by 11%, high temperature by 19% and both stresses by 79% as compared to control (100%). However, drought stress decreased transpiration rate similarly as combined drought and high temperature stresses (by 60-63%). Transpiration rate under high temperature stress compared to control slightly increased.

**Operationalising sustainability impact assessment of land use scenarios in developing countries: A stakeholder-based approach with case studies in China, India, Indonesia, Kenya, and Tunisia**

*Hannes König (Leibniz-Zentrum für Agrarlandschaftsforschung (ZALF) e.V.)*

Growing populations, continued economic development, and limited natural resources are critical factors affecting sustainable development. Ex-ante impact assessment is an emerging field poised at the science-policy interface and is used to assess the potential impacts of policy while also exploring trade-offs between economic, social and environmental sustainability targets. The Framework for Participatory Impact Assessment (FoPIA) was selected for this study because it allows for the integration of various sustainability dimensions, the handling of complexity, and the incorporation of local stakeholder perceptions. FoPIA was adapted to the conditions of developing countries, and its implementation was demonstrated in five selected case studies. Based on the findings from the five case studies, FoPIA was found to be suitable for implementing the impact assessment at case study level while ensuring a high level of transparency. FoPIA supports the identification of causal relationships underlying regional land use problems, facilitates communication among stakeholders and illustrates the effects of alternative decision options with respect to all three dimensions of sustainable development.

**CO2 flux measurements in the vegetation period of winter wheat in Lubelskie province**

*Jaromir Krzyszczak (Institute of Agrophysics of the Polish Academy of Sciences)*; *Piotr Baranowski (Institute of Agrophysics of the Polish Academy of Sciences)*; *Cezary Sławiński (Institute of Agrophysics of the Polish Academy of Sciences)*

The assessment of net ecosystem exchange and respiration of ecosystem of terrestrial ecosystems is necessary to improve our knowledge about carbon cycle in nature. Here we present measurements of $CO_2$ fluxes for a winter wheat temperate climate ecosystem (buckwheat in the previous years) located in the Lubelskie province (eastern Poland) using a closed dynamic chamber system over a 2013 vegetation season. Measurements of carbon dioxide emission from soils and its assimilation by plants were carried out on a typical for Lubelskie highland arable land located in the Stany Nowe (N50$^{o}$49’17.0555”, E22$^{o}$16’28.51”, height 243m above sea level) using the set of two chambers (transparent and dark). Carbon dioxide fluxes have been measured by EGM-4 PP Systems sensor during fixed stages of the plant growing season. During the experiment carbon emission from soil ranged from 151 to 764 mg $C \cdot m^{-2} \cdot h^{-1}$ and its assimilation by plants ranged from -148 (emission) to 1585 mg $C \cdot m^{-2} \cdot h^{-1}$. We found substantial differences in emission and assimilation of carbon in the winter wheat ecosystem. This, along with other measurements (meteorological factors and soil and plant parameters) carried out in the Stany Nowe can be used as a high quality data to verify various models of emission of greenhouse gases. The chamber technique occurs to be a useful tool for determining carbon dioxide exchange between ecosystem surface and the atmosphere.

**Relationships between temperature humidity index, mortality, milk yield and composition in Italian dairy cows**

*Nicola Lacetera (University of Tuscia)*; *Andrea Vitali (University of Tuscia)*; *Umberto Bernabucci (University of Tuscia)*; *Alessandro Nardone (University of Tuscia)*

The aim of this presentation is to illustrate the activities performed by the LiveM-Task L1.2. group based at the University of Tuscia, Viterbo, Italy. Three different pluriannual databases were built to perform retrospective studies aimed at establishing the relationships between temperature humidity index (THI) and parameters of interest for dairy cow farms. The THI combines temperature and humidity in a single value and has been widely used to quantify heat stress in farm animals. The first database was built to assess the relationships between THI and mortality over a 6 yr period (2002-2007); the second one was a 7 yr database (2001-2007) which was built to establish the relationships between THI and milk yield; the last database included THI, milk somatic cell counts, total bacterial counts, fat and protein percentages data collected over a 7 yr period (2003-2009). The analysis of the three databases provided several equations which demonstrated and quantified an increase of mortality, reduction of milk yield and a worsening of milk quality in hot environment. Results of these analyzes authorized speculations about risks for dairy cows and their productivity in a warming planet. Furthermore, the same results are being utilized by economists also working within MACSUR at the University of Tuscia for an integrated study aimed at establishing the economic impact of climate change in the dairy sector. Combining this information with climate change regional scenarios might permit prediction of the impact of global warming and identification of adaptation measures that are appropriate for specific contexts.

**Farm level dynamic economic modelling of crop rotation with adaptation practices**

*Heikki Lehtonen (MTT Agrifood Research Finland)*; *Xing Liu (MTT Agrifood Research Finland)*; *Tuomo Purola (MTT Agrifood Research Finland)*; *Reimund Rötter (MTT Agrifood Research Finland)*; *Taru Palosuo (MTT Agrifood Research Finland)*

Agriculture is facing increasing challenges under volatile commodity markets, on-going climate change with more frequent extreme weather events and tightened environmental constraints. Crop rotation is considered essential and may even gain more importance for sustainable farming in the context of climate change challenges while monocropping is expected to become increasingly problematic. This is, among others, because of increasing plant protection challenges due to warmer climate which is expected to result in severe droughts, heavy rainfall and waterlogging in northern latitudes more frequently. Such changes require improved soil structure and water retention, also aided by crop rotations, to avoid yield losses. Our objective is to build and apply a dynamic optimization model of farm level crop rotation on many field parcels over 30-40 years. The model takes into account various adaptation management methods such as fungicide treatment, soil improvements such as liming, and nitrogen fertilization, simultaneously with dynamic crop rotation choices. However, these management options come along with costs. Using the model, outcomes of crop growth simulation modeling can be included into economic analysis. Simulated new cultivars, suited for a longer growing season, can be defined as alternatives to current cultivars, both having specific nutrient and other input requirements such as water, labor or pesticides. The model is used in evaluating the value of future cultivars and other management practices in climate and socio-economic scenarios. The first results show that expected market prices have major impacts on the management choices, the resulting yield levels, production and income over time.

**Specific problems and solutions in climate change adaptation in North Savo region**

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Crop production for feed dominates land use in North Savo in eastern Finland. The value of dairy and beef production is appr. 70 % of the total value of agricultural production of the region. In climate change adaptation research we are especially interested in dairy and meat sectors, which are directly dependent on the development of productivity of crop production. Climate change implies changes in cereals and forage crop yields and nutritive quality. There are most likely increasing problems and risks related to overwintering and growing periods. Grass silage is mainly self-produced on farms and most often there is no market for silage. Silage production and use are vulnerable to changes in local climate, because lost yield cannot be easily replaced from market. Risks and costs due to increasing inter-annual yield volatility can be reduced by good management practices, such as crop rotation, plant protection, soil improvements and better crop protection against plant diseases.

However the profitability of such measures is dependent on market and policy conditions. Nevertheless new cultivars and species, as well as various options for production and risk management, are most likely needed in future climate. Some adaptations may have multiple benefits which however may realize only in medium or long run. It is important to safeguard the most important and obviously needed adaptations, and identify market and socio-economic conditions which inhibit farmers from necessary adaptations and lead to reduced productivity and increased production costs.

**Application of Biome-BGC MuSo in managed grassland ecosystems in the Euro-Mediteranean region**

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Simulation of the biogeochemical cycles of extensively and intensively managed grasslands and croplands are of particular interest due to the strong connection between ecosystem production, animal husbandry and food security. In the frame of MACSUR LiveM activities, we conducted a series of „blind tests" (i.e. uncalibrated model simulations with previously optimized model) on differently managed grasslands within Europe and Israel. We used the latest version of Biome-BGC MuSo model, the modified version of the widely used biogeochemical Biome-BGC model. Biome-BGC MuSo contains structural improvements, development of management modules, and the extension of the model to simulate herbaceouos ecosystem carbon and water cycles more faithfully.

The studied ecosystems were meadows and pastures located in a variety of climate zones from the Atlantic sector to Central Europe, including Mediterranean sites. Managements were intensive and extensive grazing or mowing with or without different kind of fertilizers. Under similar options we simulated ecosystem variables, e.g. Gross Primary Production (GPP) and Net Ecosystem Exchange (NEE).

Our experiences show that different sites have different sensitivity to the parameters (maximum root depth, soil parameters, etc.), but overall the model provided realistic fluxes. Experiences gained during the blind tests led us to further improve the model.

Biome-BGC MuSo is available as a standalone model in personal computers, 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.

**Crop responses to soil salinization in the context of climate change**

*Albino Maggio (Fondazione Medes)*

Soil salinization is an expanding phenomenon, exacerbated by climate change. Mediterranean environments are exposed to salinization. Assessment of the specific crop-environment interactions is therefore critical for these areas. In this context, models to evaluate crop response to salinity, including applications of SWAP and Hydrus models to study viable water management options and water movement in salinized agricultural zones can contribute to identify optimal mitigation strategies.

**Climate change impacts and adaptation strategies evaluation on staple food crops in different agro-climatic zones**

*Valentina Mereu (University of Sassari and Euro-Mediterranean Center on Climate Change)*; *Donatella Spano (University of Sassari and Euro-Mediterranean Center on Climate Change)*; *Andrea Gallo (University of Sassari)*; *Gianluca Carboni (AGRIS - Agricultural Research Agency of Sardinia)*

Increasing temperatures, changed precipitation patterns and more frequent extreme events may lead to an increase in crop failure and to a substantial decrease of crop yields. The assessment of climate change impacts on agricultural sector has a particular interest to stakeholders and policy makers, in order to identify specific agricultural sectors and agro-climatic zones that could be more vulnerable to changes in climatic conditions and to develop the most appropriate policies to cope with these threats. For these reasons, the evaluation of climate change impacts for key crops in different agro-climatic zones was made exploring climate uncertainty and focusing on short period monitoring, which is particularly useful for food security and risk management. The analysis was made using the DSSAT-CSM (Decision Support System for Agrotechnology Transfer - Cropping System Model) software, version 4.5. Crop models implemented into DSSAT-CSM were used, for each selected crop, to evaluate climate change impacts on crop production. Multiple combinations of soils and climate conditions, crop management and varieties were considered for different agro-climatic zones. The climate impact was assessed using future climate projections, statistically and/or dynamically downscaled, for the specific areas. Direct and indirect effects of different $CO_2$ concentrations, projected for the future periods, were separately explored to estimate their effects on crops. Finally, several adaptation strategies were evaluated with the aim to reduce the negative impact of climate change on crop production. The results of the study, analysed at local and regional scale, will be discussed.

**Sustainable food consumption as a mitigation and adaptation strategy**

*Anna Birgitte Milford (Norwegian Agricultural Economics Research Institute (NILF))*

Studies of GHG emissions from agriculture show that there are large differences in emissions from different products. In addition some foods require more land and water resources than others, which

mean that in a future with food scarcity, moving from less to more sustainable food may become a necessity for there to be enough food for everyone. A changing of consumption and production from less to more sustainable food is thus both a mitigation strategy, as well as an adaptation strategy if climate change results in less available agricultural land and water resources, and more food loss due to more extreme weather conditions.

Forecasting the economic consequences of climate change on agricultural production cannot be done without taking into account our future consumption patterns. What will be produced will always to a large extent be a result of what is being demanded by consumers.

This is a presentation of two ongoing projects related to this theme. One is a newly started project on factors which influence meat consumption. In a cross-country regression analysis we will estimate the importance of different factors such as income, price levels and degree of urbanization. We are particularly interested in the interlinkages between meat production and consumption at national levels.

The other project looks at typical diets in England, Spain and Norway, and will estimate through a multi objective optimization process how the diets can be changed, through taxes and subsidies, towards a diet which is both more healthy and climate friendly.

**Bayesian inference of a dynamic vegetation model for grassland**

*Julien Minet (University of Liège)*; *Eric Laloy (SCK-CEN)*; *Bernard Tychon (University of Liège)*; *Louis François (University of Liège)*

As a part of the MACSUR task L2.4, we probabilistically calibrated the CARAIB dynamic vegetation model by Markov chain Monte Carlo (MCMC) simulation with the $DREAM_{ZS}$ sampler.. CARAIB is a mechanistic model that calculates the carbon assimilation of the vegetation as a function of the soil and climatic conditions, and can thus be used for simulating grassland production under cutting or grazing management.
Bayesian model inversion was performed at 4 grassland sites across Europe: Oensingen, CH; Grillenburg, DE; Laqueuille, FR and Monte-Bodone, IT. Four daily measured variables from these sites: the Gross Primary Productivity (GPP), Net Ecosystem Exchange (NEE), Evapotranspiration (ET) and Soil Water Content (SWC) were used to sample 10 parameters related to rooting depth, stomatal conductance, specific leaf area, carbon-nitrogen ratio and water stresses. The maximized likelihood function therefore involved four objectives, whereas the applied Bayesian framework allowed for assessing the so called parameter posterior probability density function (pdf), which quantifies model parameter uncertainty caused by measurement and model errors. Sampling trials were performed using merged data from all sites (all-sites-sampling) and for each site (site-specific sampling) separately.
The derived posterior parameter pdfs from the all-sites sampling and site-specific sampling runs showed differences in relation with the specificities of each site. Analysis of these distributions also revealed model sensitivity to parameters conditioned on the measured data, as well as parameter correlations.

**Incorporating uncertainty in a deterministic agricultural sector model**

*Klaus Mittenzwei (Norwegian Agricultural Economics Research Institute (NILF))*

Climate-induced uncertainty in crop yields is introduced in the Norwegian sector model Jordmod. The model is comprised of a supply module in which profits for more than 300 regional farms are maximized and a market module which maximizes social welfare in the agricultural sector. In the supply module, farmers determine their plant decisions and crop input levels (N-fertilizer) subject to a discrete number of weather outcomes affecting crop yields. After that, a specific weather distribution is chosen

determining crop yields. The resulting input-output mix at farm level makes up the supply side of the commodity markets which together with linear demand functions determine equilibrium levels. The procedure is repeated for each discrete weather outcome. Note that plant decisions and crop input levels remain the same for all weather outcomes as farmers face the same uncertainty during all repetitions, but crop yield will vary. Hence, equilibrium prices and quantities will vary as well allowing their representation as stochastic distributions. In a preliminary empirical application, the stochastic results are contrasted with the deterministic results based on the mean values of the weather outcomes. This comparison will shed light on the potential error made by neglecting uncertainty at the farm level.

**A crop modeling response to economists' wishlists**

*Christoph Mueller (Potsdam Institute of Climate Impact Research (PIK))*

Assessments of climate change impacts on agricultural markets and land-use patterns rely on quantification of climate change impacts on the spatial patterns of land productivity. We supply a set of climate impact scenarios on agricultural land productivity derived from two climate models and two biophysical crop growth models to account for some of the uncertainty inherent in climate and impact models. Aggregation in space and time leads to information losses that can determine climate change impacts on agricultural markets and land-use patterns because often aggregation is across steep gradients from low to high impacts or from increases to decreases. The four climate change impact scenarios supplied here were designed to represent the most significant impacts (high emission scenario only, assumed ineffectiveness of carbon dioxide fertilization on agricultural yields, no adjustments in management) but are consistent with the assumption that changes in agricultural practices are covered in the economic models. Globally, production of individual crops decrease by 10 to 38% under these climate change scenarios, with large uncertainties in spatial patterns that are determined by both the uncertainty in climate projections and the choice of impact model. This uncertainty in climate impact on crop productivity needs to be considered by economic assessments of climate change.

**Adaptation to climate change of Italian agricultural systems: the analysis of explorative scenarios.**

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Adaptation of agricultural systems to climate uncertainties requires the construction of scenarios that should take into account the complexities of socio-ecological systems of a specific local context. Adaptation scenarios of agricultural systems are not making forecasts or predictions, but prospective futures or future paths. They can facilitate our understanding of how systems work and evolve. Adaptation processes of agricultural systems involve a variety of changes in local practices and social organization. The development of adaptation scenarios at farm level entails a clear understanding of farmers' frames that are mediated by their interests, experiences and internal and external forces. Farmers' frames is the way in which farmers frame climate issues emphasizing vulnerabilities, uncertainties and opportunities (i.e: impacts on their farming systems) and open the window for searching adaptation strategies.

This study reports on the methodologies for the development of explorative scenarios (i.e., scenarios that explore the future from a variety of perspectives) for the climate change adaptation of four

agricultural systems (intensive dairy cattle, extensive dairy sheep, rice farming and horticulture) in the Oristano regional pilot study in Italy. Explorative scenarios were used to explore trends into the future from the past and present. Three research steps were followed: (i) in the first step farmers' perceptions and prospective through semi-structured interviews and questionnaires were analysed; (ii) in the second step the evolution of the agricultural systems (i.e. temporal and spatial) was evaluated; (iii) the third step examined multiple stakeholders' outlooks about farm-level possible adaptive strategies through interactive workshops.

**Centre for Regional change in the Earth System**

*Jørgen Eivind Olesen (Aarhus University)*; *John Porter (University of Copenhagen)*; *Jens Christensen (Danish Meterorological Institute)*

Centre for Regionalchange in the Earth System (CRES, cres-centre.net) is funded by the DanishStrategic Research Council for the period 2009-2014 and is coordinated by theDanish Meteorological Institute. CRES has established a coordinated researcheffort aiming to improve societal preparedness for climate change, inparticular for Denmark. The overall objective of CRES is to extend knowledge ofand reduce the uncertainties surrounding regional climate change and itsimpacts and thereby support future climate change adaptation and mitigationpolicies. Some of the objectives that also have large synergies with theeffects in the CropM theme of MACSUR are a) to reduce uncertainty surroundingregional climate change and its impacts for the period 2020-2050 by improvingmodel formulation and process understanding; b) identify key changes andtipping points in the regional hydrological system, agriculture, freshwater andestuarine ecosystems caused by changes in seasonality, dynamics and extremeevents of precipitation, droughts, heat waves and sea level rise; c) quantifyconfidence and uncertainties in predictions of future regional climate and itsimpacts, by improving the statistical methodology and substance and byintegrating interdisciplinary risk analyses; d) interpret these results inrelation to risk management approaches for climate change adaptation andmitigation. Studies in CRES of particular interest to MACSUR include a)Estimation on generic crop model uncertainties in projection of climate changeimpacts on wheat year, b) Assessment of uncertainties in projected effects onwater balance, crop productivity and nitrate leaching of changes in land use,climate and assessment models.

**Reconciling estimates of climate change effects on nitrate leaching from agricultural crops**

*Jørgen Eivind Olesen (Aarhus University)*; *Mohamed Jabloun (Aarhus University)*; *Kirsten Schelde (Aarhus University)*

Nitrate leaching from agricultural systems constitutes a severe environmental effect in regions with valuable groundwater resources and vulnerable aquatic ecosystems. Therefore cropping systems should in many parts of Europe reduce the amount of nitrate leached from the root zone. Since soil nitrogen transformation and loss processes are highly influenced by climate, including temperature and precipitation, estimates of climate change effects on nitrate leaching is in high demand for evaluating future groundwater and surface water protection policies. Modelling studies using both the FASSET and Daisy models for cereal crops as well as arable crop rotations in Denmark have shown increased nitrate leaching under projected climate change. Sensitivity analyses using these models have shown a higher response to changes in temperature than to precipitation, although in particular precipitation responses differ between soil types. Simulations for crop rotations show that current catch crop management may not be sufficient to maintain low nitrate leaching levels in future. These effects of temperature and precipitation as well as crop management are confirmed in an empirical analysis of nitrate leaching from a long-term cropping system experiment in Denmark. The main uncertainties on climate change effects on future nitrate leaching appears to be related to effects of climate change on soil organic matter and

thus on the amount of soil total N available for mineralization as well as the effects of enhanced atmospheric CO2 concentration on crop residue quality and N mineralization.

**Modelling adaptation of wheat cultivar to increasing temperatures and heat stress**

*Jørgen Eivind Olesen (Aarhus University)*; *Marija Vignjevic (Aarhus University)*; *Bernd Wollenweber (Aarhus University)*

Climate change is expected to lead to yield reductions in cereals due to effects on both growth duration and physiological processes affecting assimilation and translocation to grains. However, some of these negative effects may be alleviated through plant breeding. A pot experiment with selected spring wheat varieties exposed to post anthesis heat stress (35 oC for 5 days) showed that the major factor affecting variety differences in heat tolerance was related to effects on green leaf area duration after heat stress. A field experiment with the same selected spring wheat varieties showed large differences between the varieties in crop development and in biomass. The data were used to calibrate the FASSET and Sirius crop models using a sequenced calibration procedure. Both models simulated crop growth and yield well. A sensitivity analysis with increasing temperature showed declining yields for both models with higher rates of yield reduction at temperature increases above 3oC. The models agreed on the pattern of yield decline between cultivars, with larger yield declines being related to earliness. The FASSET model was further modified to simulate effects of cultivar differences in remobilization of water soluble carbohydrates and effects of post-anthesis heat stress on crop yield. Effects of variation in threshold temperature for heat stress as well as response rate are tested.

**Effect of Increased Somatic Cell Count and Replacement Rate on Greenhouse Gas Emissions in Norwegian Dairy Herds**

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Dairy sector contributes around 4% of global greenhouse gas (GHG) emissions, of which 2/3 and 1/3 are attributed to milk and meat production, respectively. The main GHGs released from dairy farms are methane, nitrous oxide and carbon dioxide. The increased trend in emissions has stimulated research evaluating alternative mitigation options. Much of the work to date has focused on animal breeding, dietary factors and rumen manipulation. There have been little studies assessing the impact of secondary factors such as animal health on emissions at farm level. Production losses associated with udder health are significant. Somatic cell count (SCC) is an indicator on udder health. In Norway, around 45, 60 and 70% of cows in a dairy herd at first, second and third lactation are expected to have SCC of 50,000 cells/ml and above. Another indirect factor is replacement rate. Increasing the replacement rate due to health disorders, infertility and reduced milk yield is likely to increase the total farm emissions if the milking heifer replacements are kept in the herd. In this study, the impact of elevated SCC (200,000 cells/ml and above) and replacement rate on farm GHG emissions was evaluated. HolosNor, a farm scale model adapting IPCC methodology was used to estimate net farm GHG emissions. Preliminary results indicate an increasing trend in emissions (per kg milk and meat) as the SCC increases. Results suggest that animal health should be considered as an indirect mitigation strategy; however, further studies are required to enable comparisons of different farming systems.

**A comprehensive climate characterization of the Oristano (Sardinia) regional pilot case study.**

*Massimiliano Pasqui (CNR - IBIMET)*; *Sara Quaresima (CRA - CMA )*; *Rodica Tomozeiu (ARPA - SIMC)*; *Gabriele Dono (DAFNE - Tuscia University)*; *Luca Doro (Sassari University)*; *Raffaele Cortignani (DAFNE - Tuscia University)*; *Luigi Ledda (Sassari University)*; *Pier Paolo Roggero (Sassari University)*

In order to assess probability distributions of critical response variables in a full crop modelling system, a complete climate characterization has been implemented to identify principal variability components in the Oristano (Sardinia) regional pilot study area with a particular emphasis on current vs near future climate.

The past climate variability along with the near future climate perspective (2020-2030) has been analyzed to highlight and address the transition period and to better identify effective adaptive response of cropping systems to climate change.

Surface atmospheric fields as temperature and rainfall, along with large scale atmospheric circulation types have been analysed to provide a comprehensive nexus for seasonal and sub-seasonal variability over the recent past and near future in the Central Mediterranean basin. Furthermore a robust stratification of sub-seasonal atmospheric regimes as wet/dry spells and hot/cold spells has been defined to identify main forcing mechanisms over specific critical periods for agronomical practices and studying their links with potential remote climate centre of actions.

**Determining the impact of soil regionalization and climate change on wheat and timothy grass yield in southeastern Norway**

*Tomas Persson (Norwegian Institute for Agricultural and Environmental Research (Bioforsk))*; *Sigrun Kværnø (Norwegian Institute for Agricultural and Environmental Research (Bioforsk))*; *Mats Höglind (Norwegian Institute for Agricultural and Environmental Research (Bioforsk))*

Southeastern Norway is characterized by variable soils, which affect its agricultural productivity. The region is dominated by cereal production, but livestock farming with forage crops has increased the latest years. Climate and socio-economic changes could entail a shift from the current production areas of cereal and forage crops. In this study we used the mechanistic models CSM-CERES and LINGRA to evaluate impacts of climate change and soil variability on wheat and timothy yields in Akerhus and Østfold Counties in Southeastern Norway. The models were run for historical (1961-90) and projected future (2046-2065) climatic conditions, and for four soil regionalizations of different resolution (1, 5, 16 and 76 representative soil profiles). The extrapolation of soil characteristics was based on similarities in texture, organic matter, layering and water holding capacity. Across the whole region, there were small differences in both spring wheat and timothy yield between the different soil regionalization resolutions. However, within certain districts within the region the differences in wheat grain yield and timothy biomass yield among the soil resolutions were up to 20 percent. These results indicate that a relatively detailed resolution of the soil proporties is preferred to better understand the impact of shifts in production between cereals and forage grasses on yield level if spatial variability within regions is considered . The climate change scenario used indicated increased yields of both crop types in a future climate. Further steps could include a weighting of the wheat and timothy production across soils according to economic analyses.

**Using indicators to inform agricultural decision making**

*Giovanni Quaranta (Fondazione Medes)*; *Rosanna Salvia*

Most farmers carry out several types of activity of their land (different crops or livestock) and use a wide range of agricultural techniques. They often need to address one of the following questions. How would the economic returns from my various activities be affected by using production practices which have different effects on soil conservation or degradation? How would the economic returns from these activities change, if the product price and/or subsidies structure and/or input costs changed? ManPrAs is a tool for Agricultural Management Practices Assessment developed. It is a method, to assess the sustainability of different agricultural practices by combining their soil conservation index (SCI) with their economic results (Gross Margin-GM). It also simulates the impact of alternative crops and management techniques on soil degradation, farm profitability and other socio-economic aspects. ManPrAs is strongly user-orientated and is a powerful simulation tool for farmers and stakeholders involved in land management.

**How does a crop model calibrated to national yield data perform on the field scale?**

*Livia Rasche (University Hamburg)*; *Ruth Sos Del Diego (University Hamburg)*

Crop models used as parts of integrated assessments often need to be run on regional, national and global scales. Calibration is an important step in the application procedure, yet on scales like this the process needs to be simplified in order to meet data requirements and computational limits. The question arises if a model calibrated in such a “simple” fashion still performs adequately at field scale, and if parameters not calibrated in the process can nevertheless be used with some confidence in later stages of the assessment.

To answer this question, we applied the crop model EPIC to the simulation of sugarcane in Sao Paulo, Brazil. We once calibrated the model using Bayesian calibration to data on yield, aboveground biomass, and root weight measured in four years on two field trials in Sao Paulo. For the second calibration we used a simplified approach and calibrated the model only to FAOSTAT yield data for the whole of Brazil. Both calibrated models were applied to the simulation of stalk yield, aboveground biomass and root weight on a third field trial, and to the simulation of mean yields in Sao Paulo.

The results showed that both models were able to adequately depict yields on both scales, but that the model calibrated to only national yield data was not able to accurately simulate root biomass, and to a lesser degree aboveground biomass.

We conclude that a simplified calibration performs adequately on both scales, but that non-calibrated parameters may only be used with caution.

**Agrimod: The Agricultural Modelling Knowledge Hub Website**

*Mike Rivington (The James Hutton Institute)*

Agrimod is a new web-based Agricultural Modelling Knowledge Hub covering crop, livestock and trade models and the data they require, plus a wide range of supporting tools and resources. The purpose is to address the growing need, particularly in developing countries, of building national capabilities for researching agriculture and food security using models. To support research in this area, Agrimod provides a facility enabling users to access information and data needed to more successfully develop and employ agricultural modelling. Registered users can add new information about models, data, case studies, training, funding sources etc., whilst also being able to edit existing content and contribute to discussion threads on key modelling issues. It will serve as a model, data and case study inventory. The vision is to unite the existing agricultural modelling community by providing a platform whereby models can be showcased, their applications discussed and new collaborations built, streamlining the process by

which new model activities are developed. Moreover, Agrimod is intended to be a user–friendly information portal to people in other areas of research or new to agricultural modelling, looking to develop skills and acquire first-hand knowledge on agricultural modelling research. Thus Agrimod serves as a central knowledge hub for information on agricultural modelling activities worldwide and can be used by MACSUR as a complimentary information dissemination tool.

**IC-FAR: Linking Long Term Observatories with Crop Systems Modeling For a better understanding of Climate Change Impact, and Adaptation Strategies for Italian Cropping Systems**

*Pier Paolo Roggero (Università degli Studi di Sassari)*; *Antonio Pulina (Università degli Studi di Sassari)*; *Guido Baldoni (Università Alma Mater Bologna)*; *Bruno Basso (Università degli Studi della Basilicata)*; *Antonio Berti (Università degli Studi di Padova)*; *Simone Orlandini (Università degli Studi di Firenze)*; *Francesco Danuso (Università degli Studi di Udine)*; *Massimiliano Pasqui (Consiglio Nazionale delle Ricerche)*; *Marco Toderi (Università Politecnica delle Marche, Ancona)*; *Marco Mazzoncini (Università degli Studi di Pisa)*; *Carlo Grignani (Università degli Studi di Torino)*; *Francesco Tei (Università degli Studi di Perugia)*; *Domenico Ventrella (Consiglio per la Ricerca e la Sperimentazione in Agricoltura, Bari)*

The IC-FAR project (2013-2016), funded by the Italian ministry of University, Research and Education, aims to use datasets from 16 Italian long term agronomic experiments (LTEs) to assess the reliability of different cropping system models over a range of Mediterranean environments and cropping systems. The selected models will be used for scenario and uncertainty analyses *vs* near-future climate change. The LTEs are located in seven sites: Turin, Padua, Bologna, Ancona, Pisa, Perugia, Foggia. The project's is linked to international projects such as MACSUR, AgMIP, ANAEE, ESFRI and GRA, and has model developer teams as associate partners.

IC-FAR is structured infive WPs. WP1 is focused on building a common dataset and sampling protocols. The field data will be implemented inthe WP2 to calibrate, validate and assess the performances of different models across Italian environments.An uncertainty analysis will be performed in relation to the model types, cropping system typologies and climate scenarios (WP3). WP4 and WP5 are focused on capacity building on modeling and on dissemination, including networking with other European LTE platforms (WP4), and to the project coordination (WP5).

The next step of IC-FAR will be the design and realization of a special issue summarizing a selection of the most important results from the LTEs, that will be the starting point towards the full implementation of the data sharing policy of this project.

**Combining modeling and stakeholder involvement to build community adaptive responses to climate change in a Mediterranean agricultural district**

*Pier Paolo Roggero (University of Sassari)*; *Giovanna Seddaiu (University of Sassari)*; *Luigi Ledda (University of Sassari)*; *Luca Doro (University of Sassari)*; *Paolo Deligios (University of Sassari)*; *Thi Phuoc Lai Nguyen (University of Sassari)*; *Massimiliano Pasqui (IBIMET-CNR)*; *Sara Quaresima (Agricultural Research Council)*; *Nicola Lacetera (University of Tuscia)*; *Raffaele Cortignani (University of Tuscia)*; *Gabriele Dono (University of Tuscia)*

The case study area (54,000 ha) is located at Oristano, Italy. The main cropping systems are based on forages (silage maize, Italian ryegrass and alfalfa under irrigation, winter cereals and grasslands under rainfed conditions), rainfed cereals (durum wheat, barley), vegetables (e.g. artichokes), rice, citrus, olives and vineyards. Some 36,000 ha are served by irrigation. The area includes the dairy cows cooperative system of Arborea (30,000 cows, 5500 ha, nitrate vulnerable zone). The rainfed dairy sheep includes 372,000 sheep and a number of small milk processing plants.

The research aims to support adaptive responses to climate change through the combination of modeling approaches and stakeholder engagement. Present (2000-2010) and future (2020-2030) climatic scenarios were developed by combining global climate models with Regional Atmospheric Modelling Systems to produce calibrated time series of daily temperature and precipitation for the case study. The EPIC model was calibrated to simulate the impact of climate scenarios on the main cropping systems. The impact of THIndex on milk yield, milk quality and mortality was also simulated for dairy cows. A territorial farm-type Discrete Stochastic Programming model was implemented to simulate choices for thirteen farming typologies as influenced by crop yields and water consumptions.

Participatory activities, including field experiments, interviews, focus groups and interactive workshops, involved farmers and other stakeholders in the most critical phases of the research. The assessment of uncertainties and opportunities were proposed as a basis for discussion with policy makers to identify priorities for agro-climatic measures in 2014-2020.

**Environmental impacts of grassland management and livestock production**

*Susanne Rolinski (Potsdam Institute of Climate Impact Research (PIK)Telegrafenberg A31D-14473 Potsdam)*; *Isabelle Weindl (Potsdam Institute of Climate Impact Research (PIK)Telegrafenberg A31D-14473 Potsdam)*; *Jens Heinke (Potsdam Institute of Climate Impact Research (PIK)Telegrafenberg A31D-14473 Potsdam)*; *Benjamin Bodirsky (Potsdam Institute of Climate Impact Research (PIK)Telegrafenberg A31D-14473 Potsdam)*; *Anne Biewald (Potsdam Institute of Climate Impact Research (PIK)Telegrafenberg A31D-14473 Potsdam)*; *Hermann Lotze-Campen (Potsdam Institute of Climate Impact Research (PIK)Telegrafenberg A31D-14473 Potsdam)*

The potential of grasslands to sequester carbon and provide feed for livestock production depends on the one hand on climatic conditions but secondly on management and grazing pressure. Using a global vegetation model considering different management and grazing options, effects of livestock density on primary productivity can be assessed. It is expected that low animal densities enhance productivity whereas increasing grazing pressure may deteriorate grass plants. Thus, the optimal animal density depend on the specific primary production of the pasture and optimal grazing intensity. Using these optimal grass yields, the impacts of livestock production on resource use is assessed by applying the global land use model MAgPIE. This model integrates a detailed representation of the livestock sector and integrates socio-economic regional information with spatially explicit biophysical data. With scenario analysis we analyze the impact of livestock production on future deforestation and land use. Our results indicate that the reduction of animal derived calory demand has a huge potential to spare land for nature and reduce deforestation. On the supply side, feeding efficiency gains can help to decrease demand for land and overall biomass requirements.

**Cross-cutting uncertainties in MACSUR impact projections**

*Reimund Rötter (MTT Agrifood Research Finland)*

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Projections into the future, such as climate change impact projections on crop production for a given region, or, on global food prices and trade are inherently uncertain. Uncertainty does not fall within a single discipline but is dealt with by a wide variety of disciplines, themes and problem domains. Model uncertainty pertaining to the impact modelling chain from climate via crop and livestock to economic and trade modelling is only part of the overall uncertainty*. There is also scenario uncertainty and many other known and unknown "unknowns"[1] to be considered in efforts such as MACSUR and its themes (CropM, LiveM, TradeM) to advance model-based integrated assessment of climate change risk

assessment for agriculture and food security. Propagation of uncertainties along the climate change impact modelling chain has been portrayed as "uncertainty cascade" [2]. We will present different basic approaches for evaluating uncertainty in models. So far, studies addressing quantification and reporting of uncertainties in impact projections still largely focus on two major sources, i.e. the shares originating from climate modelling and from crop modelling. However, a more comprehensive treatment of uncertainty and how it is reported is urgently needed.

**Impact of Climate Change on Crop Land and Technological Recommendations for the Main Crops in Transylvanian Plain, Romania**

*Teodor Rusu (University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca)*

Normal 0 false false false EN-US X-NONE X-NONE The Transylvanian Plain (TP) is an important agricultural production area of Romania that is included among the areas with the lowest potential of adapting to climate changes in Europe. Thermal and hydric regime monitoring is necessary to identify and implement measures of adaptation to the impacts of climate change. Soil moisture and temperature regimes were evaluated using a set of 20 data logging stations positioned throughout the plain. Each station stores electronic data regarding ground temperature at 3 depths (10, 30, 50 cm), humidity at a depth of 10 cm, air temperature (at 1 m) and precipitation. For agricultural crops, the periods of drought and extreme temperatures require specific measures of adaptation to climate changes. During the growing season of crops in the spring (April - October) in the southeastern, southern, and eastern escarpments, precipitation decreased by 43.8 mm, the air temperature increased by 0.37°C, and the ground temperature increased by 1.91°C at a depth of 10 cm, 2.22°C at a depth of 20 cm and 2.43°C at a depth of 30 cm compared with values recorded for the northern, northwestern or western escarpments. Water requirements were ensured within an optimal time frame for 58.8-62.1% of the spring row crop growth period, with irrigation being necessary to guarantee the optimum production potential. The biologically active temperature recorded in the TP demonstrates the need to renew the division of the crop areas reported in the literature.

**MitiGate: an On-line Meta-Analysis Database of Mitigation Strategies for Enteric Methane Emissions**

*Eli Saetnan (Aberystwyth University)*; *Jolien Veneman (Aberystwyth UniversityCargill Innovation Centre)*

The animal science sector has seen a proliferation of potential mitigation strategies, aimed at tackling emissions from enteric fermentation in ruminant livestock production. By bringing together data from studies on the many mitigation options available through a structured meta-analytical approach, it is possible to evaluate the overall mitigation potential for these broad strategies as well as exploring the many factors influencing the potential of $CH_4$ mitigation strategies. Such quantification of the different mitigation strategies will allow for better estimation of mitigation potential on different levels (animal, farm and sector scale) in modelling efforts. Also quantification is important to determine the strategies that show the best potential in lowering methane emissions and hence can be instrumental in policy recommendations. A database has been established through an initial extensive structured search of published literature on the topic. For each relevant paper identified, a range of meta-data have been extracted including information on the study design, mitigation strategy, animal husbandry, diet and methane emissions. By creating a database with multiple levels of moderator coding, we have provided a flexible platform for future meta-analyses at many levels of aggregation. Studies can then in future be aggregated at the level most appropriate for specific modelling or policy recommendations. This comprehensive database is being made available on-line through a user-friendly web interface. The web-

site provides a facility for open access to the database, as well as future updates of the database as more research is published on the topic.

**Predicting the optimum land use at any location for any future scenario (CLIMSAVE/IMPRESSIONS)**

*Daniel Sandars (Cranfield University)*; *Eric Audsley (Cranfield University)*; *Ian Holman (Cranfield University)*

Given any socio-, techno-, economic scenario and location specific soil and climate scenario, the farm model predicts the most profitable land use at that location. This model is encapsulated within a Europe-wide interactive interface, to allow adaptation and mitigation options to be explored by any user. With 5 climate models and 19 parameters, the user can study the sensitivity of the results to the chosen scenario settings. A scenario's land use can be classified as intensive arable, intensive grassland, extensive grassland, forestry, or abandoned depending on potential profitability.

**Interrelationship between evaluation metrics to assess agro-ecological models**

*Mattia Sanna (Department of Agricultural and Environmental Sciences - Production, Landscape, Agroenergy - University of Milan)*; *Marco Acutis (Department of Agricultural and Environmental Sciences - Production, Landscape, Agroenergy - University of Milan)*; *Gianni Bellocchi (Institut National de la Recherche Agronomique)*

When evaluating the performances of simulation models, the perception of the quality of the outputs may depend on the statistics used to compare simulated and observed data. In order to have a comprehensive understanding of model performance, the use of a variety of metrics is generally advocated. However, since they may be correlated, the use of two or more metrics may convey the same information, leading to redundancy. This study intends to investigate the interrelationship between evaluation metrics, with the aim of identifying the most useful set of indicators, for assessing simulation performance. Our focus is on agro-ecological modelling. Twenty-three performance indicators were selected to compare simulated and observed data of four agronomic and meteorological variables: above-ground biomass, leaf area index, hourly air relative humidity and daily solar radiation . Indicators were calculated on large data sets, collected to effectively apply correlation analysis techniques. For each variable, the interrelationship between each pair of indicators was evaluated, by computing the Spearman's rank correlation coefficient. A definition of "stable correlation" was proposed, based on the test of heterogeneity, allowing to assess whether two or more correlation coefficients are equal. An optimal subset of indicators was identified, striking a balance between number of indicators, amount of provided information and information redundancy. They are: Index of Agreement, Squared Bias, Root Mean Squared Relative Error, Pattern Index, Persistence Model Efficiency and Spearman's Correlation Coefficient. The present study was carried out in the context of CropM-LiveM cross-cutting activities of MACSUR knowledge hub.

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**Land use science in the 21st century**

*Uwe Schneider (ZMAW, University of Hamburg)*

Political, technical, environmental, and scientific developments in the last decades have affected the aims and scope of modern land use research. Attention has shifted from a relatively narrow analysis of food and non-food production to more comprehensive studies of land based ecosystem services. A

growing number of integrated assessments attempt to guide the future development of agricultural lands, managed forests, and terrestrial ecosystems in the coming decades towards efficiency and sustainability. The increasing links between distinct disciplines create many scientific opportunities but also new challenges. This talk will provide a brief summary of past achievements in integrated land use modeling and outline strategies for future development.

**Integrated land use modelling of climate change impacts – preliminary results from two Austrian case study landscapes**

*Martin Schönhart (University of Natural Resources and Life Sciences (BOKU))*; *Thomas Schauppenlehner (University of Natural Resources and Life Sciences (BOKU))*; *Erwin Schmid (University of Natural Resources and Life Sciences (BOKU))*

We present an integrated land use modelling framework (ILM) to analyze impacts of climate change and CAP reform as well as farm adaptation using economic, biotic and abiotic indicators at field, farm and landscape scales. The IML is applied on the two contrasting landscapes in the Austrian MACSUR regional pilot study. The scenarios cover climate and policy changes until 2040. The anticipated policy changes lead to declines in farm gross margins by -36% and -5% in the two landscapes, respectively. In contrast, climate change leads to higher gross margins, where farms can reach pre-reform levels on average. Environmental impacts such as removing of landscape elements and increasing fertilization can be moderated by an agri-environmental program, but the opportunity costs of program participation may increase.

**Spillovers between MACSUR and Austrian climate change research projects**

*Martin Schönhart (University of Natural Resources and Life Sciences (BOKU))*

The Austrian regional case study in MACSUR extends the methods and builds upon the results of the CC-ILA project. CC-ILA enables cooperation between landscape planners and landscape ecologists to analyse mitigation and adaptation strategies for sustainable rural land use and landscape developments in a case study landscape. Subsequent research in MACSUR includes analysis towards rural development and the improvement of the climate impact data base for grasslands. The latter is achieved by collaborating with Crop-M partner LFZ Raumberg-Gumpenstein, who is able to utilize spill-overs within the Agromet-Monitor project.

**Statistical learning approach for modelling the effects of climate change on oilseed rape yield**

*Behzad Sharif (PhD student, Aarhus University)*; *Jørgen Olesen (Professor - Section manager,Aarhus University)*; *Kirsten Schelde (Senior Researcher,Aarhus University)*

Statistical learning is a fairly new term referring to a set of supervised and unsupervised modelling and prediction techniques. It is based on traditional statistics but has been highly enhanced inspired by developments in machine learning and data mining. The main focus of statistical learning is to estimate the functions that quantify relations between several parameters and observed responses. These functions are further used for prediction, inference or a combination of both. For a particular case of quantitative responses, regularization techniques in regression are developed to overcome the weaknesses of ordinary least square (OLS) regression in prediction. These new shrinkage methods outperform OLS for prediction, especially in large datasets.

In this study, a large dataset of field experiments on winter oilseed rape in Denmark for 22 years (1992 to 2013) was collected. Biweekly climatic data along with sowing date, harvest date, soil type and previous crop are considered as the explanatory variables. Yield of winter oilseed rape is considered as response variable.

LASSO and Elastic Nets are the regularization techniques used to estimate the functions. Hold-one-out cross validation method for testing the prediction power reveals that these techniques are much useful in both prediction and inference. Since these techniques are included in recent versions of some software packages (e.g. R), they can be easily implemented by users at any level.

The estimated function (model) is further used to predict the oilseed rape yield responses to climate change for several scenarios using representative weather data produced by a weather generator.

**TradeM theme progress overview**

*Franz Sinabel (Austrian Institute of Economic Research (WIFO))*; *Floor Brouwer (Wageningen UR)*

TradeM is one theme of MACSUR and the major focus is on enhancing existing economic models and inspiring researchers to further develop and use models and tools. After establishing an inventory of models at the beginning of the project the next stage was used to prepare for the analysis in regional pilot studies. Case studies for three regions in Europe (North, Centre, South) are used to showcase the state of the art of agricultural modelling of climate change and food security in specific regional contexts and policy environments. In parallel efforts stakeholder participation processes are initiated, learning workshops and capacity building. Moreover, steps are to develop and test new concepts on economics for use in integrated assessment approaches dealing with risk and uncertainty.

**TradeM synergies with AGMIP**

*Franz Sinabell (Austrian Institute of Economic Research (WIFO))*; *Floor Brouwer (Wageningen UR)*

The AgMIP network started activities on intercomparison of global economic modelling at a time when MACSUR was not yet established. The achievements made so far are highly relevant for TradeM and several partners (Wageningen University, IIASA, PIK, University Bonn) are in both networks. The MOU between MACSUR and AGMIP established formal links between the two projects and TradeM is activley working on establishing further collaboration. Preparations are underway to bring together researchers of both networks in a joint workshop to be held in Austria, September 2014. The topic will be on issues related to linking local and regional models with global ones. TradeM will actively contribute to the workshop and will host a one-day side-event.

**Adaptation in Austrian cattle and milk production**

*Franz Sinabell (Austrian Institute of Economic Research WIFO)*

Climate change will pose considerable challenges to Austrian agriculture which will likely be affected by a higher frequency of extreme weather events and more volatile commodity prices. We want to analyse the spatial, economic and social dimension of this threat by exploring expected consequences for the most important agricultural activity in Austria, cattle and dairy farming. We will evaluate a broad bouquet of adaptation measures from both, the perspective of the single farm as well as from the agricultural policy perspective.
By aligning scenarios on projections of climate conditions and socio-economic developments with those developed in the EU MACSUR project (www.macsur.eu), the results will be consistent with state of the art analyses on climate change in Europe. By integrating results from a well established life cycle analysis

model that will be specified to the Austrian situation we will broaden the spectrum of existing knowledge substantially. The results will allow policy makers to base their decisions on evidence that is not limited to the Austrian situations but includes spillover effects to foreign countries as well. Farmers will
be able to benefit directly from results of this project because stakeholders from the farm sector are part of the analyses from the beginning. An additional benefit of the project is that it is closely integrated to the activities of the international network of researchers working on climate change and food security in Europe.

**MACSUR Project – The case study of vineyards. Eco-physiological and biophysical modeling applied to the growth and productivity of vineyards in northwestern Italy.**

*Federico Spanna (Regione Piemonte)*; *Claudio Cassardo (University of Turin)*; *Silvia Cavalletto (University of Turin)*; *Tiziana La Iacona (Regione Piemonte)*; *Marco Vitali (University of Turin)*; *Alessia Balanzino (University of Turin)*

Viticulture in Italy is one of the economically most important agricultural sectors. Recent research allows eco-physiological and biophysical models to develop tools able to provide support to the crop management, in terms of optimizing production performance and limiting environmental impacts.

The ability to check on a daily basis the activities of vegetative and productive phases of vines is certainly a fundamental tool for the vineyard organization and management, and for linking the trends of growth and productivity with the quality of the final product: the wine.

Since some years, some researches are taking place in the vineyards of northwestern Italy, with the aim of modeling the eco-physiological behavior of the vines, using and valorizing all available historical field data related to the vegetative and productive behavior of the vines, as well as laboratory qualitative data. At the same time, our team is evaluating two different modeling approaches: one biophysical, using the land surface scheme UTOPIA (University of TOrino land Process Interaction in Atmosphere), and another one eco-physiological.

The case-study vineyards, referred to the northwestern Italian territory, is part of a wider working program involving several integrated teams from Italy, Spain and Germany. The objectives are: to improve the use of the models used by different groups; to compare the results obtained by different modeling tools; to create a common database of field measurements; to study the relationships between vegetative-productive behaviors and quality of productions.

**AnimalChange**

*Agnes van den Pol-van Dasselaar (Wageningen UR Livestock Research)*; *Gianni Bellocchi (INRA)*; *Nick Hutchings (Aarhus University)*; *Jorgen Olesen (Aarhus University)*; *Eli Saetnan*

The EU-FP7 project AnimalChange (AN Integration of Mitigation and Adaptation options for sustainable Livestock production under climate CHANGE, http://www.animalchange.eu, 2011-2015) addresses mitigation and adaptation options and provides scientific guidance for their integration in sustainable development pathways for livestock production under climate change in Europe, Northern and Sub-Saharan Africa, and Latin America. The project provides insights, innovations, tools and models for livestock production incorporating socio-economic and environmental (particularly GHG emission) variables. Scenario studies are carried out at scales ranging from animal and pasture, to farm and to region, for given management options. A wide range of livestock production systems is included in the project. The core analytical spine of the project is a series of coupled biophysical and socio-economic

models combined with experimentation. This allows exploring future scenarios for the livestock sector under baseline and atmospheric CO2 stabilization scenarios. These scenarios are first constructed and then elaborated and enriched by breakthrough mitigation and adaptation options at field and animal scales, integrated and evaluated at farm scale and finally used to assess policy options and their socio-economic consequences. The modelling results are useful for governments, agricultural and food industry and the agricultural sector (farmers).
There are many synergies between the European activities of AnimalChange and those of the LiveM theme of MACSUR, in particular with respect to access to livestock production datasets, dialogue with stakeholders and comparison and integration of grassland and livestock models with crop and socio-economic models in pilot studies at a variety of scales.

**Stakeholder consultation on functions of grasslands in Europe**

*Agnes van den Pol-van Dasselaar (Wageningen UR Livestock Research)*

Active participation of stakeholders was one of the key objectives of the FP7-funded project MultiSward (Grant Agreement n° FP7-244983). MultiSward aimed to increase the reliance of farmers on grasslands and on multi-species swards for competitive and sustainable ruminant production systems. Stakeholders were consulted via international and national meetings. Furthermore, an on-line questionnaire on the functions of grasslands was developed in eight languages and almost 2000 valid responses were obtained from European stakeholders. All of the stakeholder groups that were identified as being important in the stakeholder analysis responded to the questionnaire: primary producers, policy makers, researchers, advisors, NGO's (for nature conservation and for protection of the environment), industry (mainly processing and seed industry) and education. This method of stakeholder consultation will be illustrated using the results on appreciation of the following functions of grasslands: adaptation to climate change, mitigating greenhouse gas emissions and carbon sequestration.

**Modelling emissions of greenhouse gases from dairy farms in the Netherlands using DairyWise**

*Agnes van den Pol-van Dasselaar (Wageningen UR)*; *Aart Evers*; *Michel de Haan*

The DairyWise model (Schils *et al*., 2007) is an empirical model that simulates technical, environmental, and financial processes on a dairy farm. The central component is the FeedSupply model that balances the herd requirements, as generated by the DairyHerd model, and the supply of home-grown feeds, as generated by the crop models for grassland and silage maize. The GrassGrowth model predicts the daily rate of DM accumulation of grass, including several feed quality parameters. Depending on (daily) grazing, the amount of grass silage is calculated which also leads to the purchase (or sale) of roughage. The final output is a farm plan describing cattle performance, crop yield, grazing, feeding, and nutrient flows and the consequences on the environment and economy. The capabilities of DairyWise will be illustrated at the MACSUR meeting in Sassari with results of dairy farming in the Netherlands: farm characteristics, economics, NPK balances and greenhouse gas emissions.

**Regional analysis of climate change impact and adaptation strategies for winter durum wheat and tomato yield cultivated in Southern Italy**

*Domenico Ventrella (Consiglio per la ricerca e la sperimentazione in agricoltura)*; *Luisa Giglio (Consiglio per la ricerca e la sperimentazione in agricoltura)*

The most important factors limiting the agriculture in Puglia region in Southern Italy are typically linked to high temperatures and low water availability. In expected future scenarios, increased challenges about such factors could further limit the crop productivity.

We adopted an approach based on the simulation analysis carried out through the DSSAT implemented into AEGIS/WIN. This tool has proved to be an useful tool to manage the analysis results about the potential future impact of two regionalized climatic scenarios within the SRES scenario A2. Anomaly_2 and Anomaly_5, based on a target increase of global temperature of 2° and 5°C. The winter durum wheat and tomato were simulated on the basis of the interaction climate-soil on a regional scale framework interesting the whole area of Puglia (about 20000 $km^2$) subdivided in about 200 units of simulation.

The wheat yield has proved to be mainly affected by the variability of precipitation. Conversely, the largest increment of temperature of spring-summer period caused a tomato yield reduction. As second step, in order to individuate the optimal adaptation strategies for both crops, a spatial analysis focused on sowing/transplanting times, nitrogen fertilization and tomato-irrigation has been carried out. The results have clearly indicated the different sensitivity of crops to climate change as influenced by the specific interaction soil-climate and an high degree of uncertainty, especially for the sowing date, depending even on small differences related to the climatic differences characterizing the areas of the Puglia territory.

**AgroC – Development and first evaluation of a model for carbon fluxes in agroecosystems**

*Lutz Weihermüller (Forschungszentrum Jülich GmbH)*

Agroecosystems are highly sensitive to climate change. To predict and describe the processes, interactions and feedbacks in the plant-soil-system a model accounting for both compartments at an appropriate level of complexity is required.
To describe the processes of crop development, crop growth, water flux, heat transport, and carbon cycling three process models were coupled and adjusted to each other: the one-dimensional soil water, heat and CO2 transport model SOILCO2, the carbon turnover model RothC, and the plant growth model SUCROS. Thereby, the main focus was on the full description of the CO2 flux into the atmosphere via plant and soil processes and finally on simulating the net ecosystem exchange. Additionally, the model was modified to work at the temporal resolution between 0.5 and 24 hours.
For a first model evaluation a winter wheat data set obtained within the TERENO Rur catchment (North Rhine-Westphalia, Germany) during 2009 was used. For model initialisation soil carbon fractions were available. Plant specific parameters and soil properties were taken from literature. Measured soil water contents, soil temperatures, crop measurements, autotrophic, and heterotrophic chamber-based respiration measurements were used for validation and calibration.
The coupled agroecosystem model AgroC described the crop development and heat transport well. Minor adjustments had to be made for carbon cycling, and to adapt the model to site specific conditions the soil hydraulic coefficients for soil water transport had to be determined by inverse modelling.

**Modelling interactions between climate and livestock pathogen transmission**

*Anthony Wilson (The Pirbright Institute)*; *Simon Gubbins*

Climate affects the transmission of livestock pathogens via multiple direct and indirect pathways. The impact of climate change on livestock pathogens is therefore complex and difficult to predict. Recent improvements in the availability of climatic data, the accumulation of epidemiological data and the development of Bayesian methodologies allow improved inferences to be made about the responses of

pathogens to climate change. We discuss recent studies demonstrating these principles and present a proposal for future work using an extensively validated model for the transmission of bluetongue virus to forecast the potential consequences of predicted environmental changes to the expected impact of the disease and efficacy of current control strategies under a range of incursion scenarios.

**LandPaKT**

*Patricia Wolf (Leibniz Institute for Agricultural Engineering Potsdam-Bornim e.V. (ATB))*; *Katja Holz (Leibniz Institute for Agricultural Engineering Potsdam-Bornim e.V. (ATB))*

LandPaKT (agricultural techniques: potentials and costs of greenhouse gas mitigation) is a joint project of the Leibniz Institute for Agricultural Engineering (ATB) and the Agricultural-Horticultural Faculty of the Humboldt University Berlin. Within the established graduate school LandPaKT, seven PhD students analyse the mitigation potentials and costs of greenhouse gas emissions systematically and merge them at the farm level. With the re-wetting of organic soils, the carbon sequestration in mineral soils depending on agricultural activities and the livestock husbandry, the most important sectors of agriculture are included in the analyses. With modelling and simulation approaches, single as well as combined measures are analysed with regard to their overall effect. Recommendations for the most-promising measures at farm level are deduced. Based on a farm model for water-use efficiency, developed within another ATB project (AgroHyd), LandPaKT aims to expand the model by greenhouse gas emissions. The graduate school started in May 2013.

The increase of the global human population with the resulting increase in food demand accompanied by changed consumption patterns urgently calls for the exploitation of mitigation options in animal husbandry. Based on the Life Cycle Assessment (LCA) approach, methodological recommendations for carbon footprint analyses for dairy farming will be developed. Furthermore, the influence of different feeds and feeding strategies on greenhouse gas emission from dairy farming will be investigated.

**Modelling approach and first results on irrigation as climate change adaptation strategy of the project NaLaMa-nT**

*Peter Zander (Leibniz-Zentrum für Agrarlandschaftsforschung (ZALF) e.V.)*; *Johannes Schuler (Leibniz-Zentrum für Agrarlandschaftsforschung (ZALF) e.V.)*; *Vera Porwollik (Leibniz-Zentrum für Agrarlandschaftsforschung (ZALF) e.V.)*; *Jens-Martin Hecker (Leibniz-Zentrum für Agrarlandschaftsforschung (ZALF) e.V.)*

The project NaLaMa-nT examines in the context of climate change sustainable development paths of land use in four different rural districts in Northern Germany. These districts were chosen along a soil-climate gradient from west to east with increasing water deficit for plant growth caused by both: decreasing rain fall and decreasing soil quality. In front of this background different trends and developments of agricultural production can be derived from analysing, modelling and comparing existing production systems and conditions of the different regions. One assumption developed from existing climate projections is that climate change will cause increasing water deficits for plant growth – especially in the eastern part of Germany.

An obvious solution is to intensify agricultural production using existing irrigation methods that can reduce the yield risk and thus stabilize income from agriculture by avoiding yield failures and increasing the overall yield level.

Therefore we build a modelling approach which allows an economic analysis both on the crop production activity level as well on the farm level. The data base comprises data representing recent

production techniques and added optional irrigation techniques. The yields and input level changes are derived from literature studies and expert interviews. The farm structure is represented and modeled based on typical farms chosen from an IACS-data farm typology with different production potentials and patterns. First results will be presented in April.

**Climate change adaptation: a farm level model to assess investment decisions in water storage**

*Matteo Zavalloni (University of Bologna)*; *Valentina Marconi (University of Bologna)*; *davide viaggi (University of Bologna)*; *Meri Raggi (University of Bologna)*

One of the potential measures suggested to cope with the changes induced by Climate Change (CC) is the construction of rainwater harvesting reservoirs . The literature has focused mostly on the water allocation management but it overlooks at the structure of the investment decision.
We analyse the investment decision in water storage facilities, for different farming specialization and under different climatic scenarios to assess the option value of the investment.
We take an interdisciplinary approach integrating climate, agronomic and economic models. CC effects are assessed by a downscale of the A1B scenario of the IPCC (Tomozeiu et al., 2010). The resulting estimated temperatures and rainfall levels are then introduced in an agronomic model, which determines the irrigation water quantity and timing for a number of crops. Finally all these elements are included in a farm level economics model, DHYMORA (Viaggi et al., 2010).
The model is applied to typical farm specializations in eastern Emilia-Romagna, including both annual and perennial crops.

**Weather data aggregation's effects on simulation of cropping systems: a model, production system and crop comparison**

*Gang Zhao*; *Holger Hoffmann*; *Lenny van Bussel*; *Andreas Enders*; *Xenia Specka*; *Carmen Sosa*; *Jagadeesh Yeluripati*; *Fulu Tao*; *Julie Constantin*; *Edmar Teixeira*; *Balasz Grosz*; *Luca Doro*; *Zhigan Zhao*; *Claas Nendel*; *Helene Raynal*; *Henrik Eckersten*; *Edwin Haas*; *Matthias Kuhnert*; *Elisabet Lewan*; *Michaela Bach*; *Kurt-Christian Kersebaum*; *Pier Roggero*; *Reimund Rötter*; *Daniel Wallach*; *Gunther Krauss*; *Stefan Siebert*; *Thomas Gaiser*; *Ralf Kiese*; *Enli Wang*; *Frank Ewert*

Interactions of climate, soil and management practices in cropping systems can be simulated at different scales to provide information for decision making. Low resolution simulation need less effort, but important details could be lost through data aggregation effects (DAEs). This paper aims to provide a general method to assess the DAEs on weather data and the simulation of cropping systems, and further investigate how the DAEs vary with changing crop models, crops, variables and production systems. A 30-year continuous cropping system was simulated for winter wheat and silage maize and potential, water-limited and water-nitrogen-limited production situations. Climate data of 1 km resolution and aggregations to resolutions of 10 to 100 km was used as input for the simulations. The data aggregation narrowed the variation of weather data and DAEs increased with increasingly coarser spatial resolution, causing the loss of hot spots in simulated results. Spatial patterns were similar across different resolutions. Consistent with DAEs on weather data, the DAEs on simulated yield (0 to 1.2 t $ha^{-1}$ for winter wheat and 0 to 1.7 t $ha^{-1}$ for silage maize), evapotranspiration (3 to 45 mm $yr^{-1}$ for winter wheat and 4 to 40 mm $yr^{-1}$ for silage maize), and water use efficiency (0.02 to 0.25 kg $m^{-3-}$ for winter wheat and 0.04 to 0.4 kg $m^{-3-}$ for silage maize), increased with coarser spatial resolution. Thus, if spatial information is needed for local management decisions, higher resolution is needed to adequately capture the spatial heterogeneity or hot spots in the region.

**Exploring yield gaps in the EU, concept and data**

*Andrea Zimmermann (University of Bonn)*

Agreeing that increased future global food demand will have to be met by production intensification rather than land use expansion (Hertel, 2011), scientists have moved to empirically analysing the causes for differences between potentially attainable yields and actually realized yields – the yield gap (Neumann et al., 2010). We aim at disentangling the effects of biophysical, economic and political impacts and farmers' response to them on crop yields by analysing yield gaps at regional scale in the EU. Apart from generally improving our understanding of yield gaps and their drivers in the EU, our analysis will contribute to the integration of economic and biophysical models at a later stage of our research. After permission to use farm level data from the European Commission, but not having received the dataset yet, particular research questions to be answered in this paper are: (1) What are suitable concepts to analyse yield gaps? (2) What are determinants of crop yields? (3) How can our data be used for a yield gap analysis in the EU? The analysis will be based on reviewing theoretical and empirical literature for research questions (1) and (2) and some descriptive data analysis for research question (3).