Seeking Sustainable Agricultural Solutions

AgMIP 6

GLOBAL WORKSHOP

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ORAL AND POSTER ABSTRACTS

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Session 1.1 Seasonal Forecasts and Climate Extremes

Oral Presentation

***Title*: Past and future weather-induced risk in crop production**

Author: Joshua Elliott
University of Chicago

Abstract: Large-scale seasonal extreme climate events in one or more important agricultural region can cause major short-term shocks to the global food system. In this talk, we discuss the state of knowledge on the impacts of climate change and extreme events on productivity and food production. We consider plausible global scenarios for 1-in-200-year food-system shocks based on modeling and historical analysis and explore the implications of changing climate on the severity, frequency, and multi-region coincidence of large-scale events in the near future.

As an example of an extreme future event in a major global breadbasket, we discuss recent work looking at the implications of a "new US Dust Bowl". The 1930s Dust Bowl was the driest and hottest for agriculture in modern U.S. history. Improvements in farming practices have dramatically increased crop productivity, but yields today are still tightly linked to climate variation and the impacts of a 1930s drought on current and future agriculture remains unclear. Simulations suggest that Dust-Bowl-type droughts today would have unprecedented consequences for agricultural productivity, with single-year losses 50% larger than the severe drought of 2012. Damages at these extremes are highly sensitive to temperature, worsening by 25% with each degree C of additional warming. Warmer temperatures with even average precipitation lead to maize losses equivalent to 1936 (the worst season for agriculture in >100 years), and warmer temperatures with consecutive droughts could make up to 85% of rainfed maize at risk to changes that may persist for decades.

Oral Presentation

***Title*: Dynamic seasonal climate forecast driven probabilistic maize yield prediction over East Africa**

Author: Geoffrey Ogutu, et al.
[1] Earth System Sciences (ESS) Group, Wageningen University, Netherlands, [2] Kenya Meteorological Service, Kenya

Abstract: Assuming that skill in seasonal climate prediction would translate to skill in impacts prediction, we use ECMWF system-4 ensemble seasonal climate hindcasts for the period 1981 to 2010 at different initialization dates before sowing to generate 15-ensemble yield predictions using a crop model (WOFOST) implemented for water-limited production and single season simulation. Yield predictions are validated against reference simulations from the same model forced by the WATCH Forcing Data ERA-Interim (WFDEI) at each grid point focussing on the dominant sowing dates in the northern region (July), equatorial region (March-April) and in the southern region (November-December). We use mean deviation, relative bias (pbias), Ranked Probability Skill Score (RPSS) and Relative Operating Curve skill Score (ROCSS) to assess regions of useful probabilistic prediction, mean errors, probabilistic skill, and tercile forecast skill respectively.

Mean yield deviations ≥500 Kg ha-1 in the equatorial regions and coastal Kenya indicate areas of beneficial probabilistic prediction. High deviation may also result from double cropping seasons corresponding to the bi-modal rainfall regimes. Under-prediction exists in all regions. Regions of high deviation show highest pbias (-20% to -80%). RPSS are low and significant in few grid points at lead month-0 except over Ethiopian highlands. Only November harvests over Ethiopia and August harvests in the equatorial regions possess significant above and below normal skill at lead month-0 and 1. From the sample sowing and harvest date combinations considered, we conclude that despite short lead times of useful pre-sowing skill, there is potential to improve yield predictions.

Session 1.1 Seasonal Forecasts and Climate Extremes

Oral Presentation

***Title*: Interdisciplinary and cross-scales Agroclimatic assessment across the U.S. Corn Belt: What have we learnt?**

Authors: Xing Liu[1] and D. Niyogi[2]
[1] Department of Agronomy, Purdue University, USA, [2] Department of Agronomy and Department of Earth, Atmospheric and Planetary Sciences, Purdue University, USA

Abstract: The U.S. Corn Belt produces nearly a third of the global corn supply and contributes nearly $150 billion annually to the U.S economy. Our group has been actively leading efforts for: (i) the synthesis related to understanding the role of weather and climate on the corn yield, and (ii) developing tools and products for making this understanding usable in the context of improved predictions by the meteorologists and improved utilization of the information by crop producers. This presentation will provide an overview of these efforts related to crop modeling and regional agro-climatic analysis for the U.S. Corn Belt, as well as developing tools and delivering datasets for farmers and researchers. The presentation will also focus on the findings from a interdisciplinary project (Making climate information Useful to Useable-U2U), we co-lead as a collaboration with crop modelers, agronomists, atmospheric and social scientists, economists, and communication / extension experts. Studies have been underway related to: crop modeling at field scale and regional scale for both contemporary and future time periods, Agro-climatic dataset development, and integrating crop simulation into land surface models for applications within weather and regional climate simulations, including local and regional drought assessment and impact on global trades. The presentation will share our findings, our experience from these multiyear interdisciplinary and cross-scales agroclimatic studies. We will also discuss the limitations, uncertainties, and our perspective on future in the crop modeling studies.

Oral Presentation

***Title*: Forecasting effects of weather extremes: El Nino's influence maize yields in Mexico**

Authors: Gideon Kruseman[1], K. Sonder[1], and V. M. Hernández Rodríguez[1]
[1] CIMMYT

Abstract: Southern Africa is facing a second year of drought in succession. Governments and private traders in the region are looking ahead where to purchase white maize to cover expected food shortages. Mexico is one of the most important white maize producing countries and in normal years has a surplus to trade on the world market. However, the severity of the 2015-2016 El Nino is likely impact on precipitation and temperature in the major rain-fed maize production areas, causing drought and/or heat stress. By forecasting the spatially explicit yield effects, policies can be put in place to ensure that production levels are sufficient to feed Mexico and have a surplus to alleviate the food shortages in Africa.

We use a combination of GIS tools, econometric techniques and crop-growth models to forecast yields and production levels.

Session 1.1 Seasonal Forecasts and Climate Extremes

Oral Presentation

***Title*: Integrated assessment of drought and adaptation scenario impacts on crop production in Austria**

Authors: Hermine Mitter[1], E. Schmid[1], and U. A. Schneider[2]
[1] Institute for Sustainable Economic Development, Department of Economics and Social Sciences, University of Natural Resources and Life Sciences Vienna, Austria, [2] Center for Earth System Research and Sustainability, Research Unit Sustainability and Global Change, University of Hamburg, Germany

Abstract: Drought information systems for agricultural decision-making typically focus on agronomic indicators. We extend these approaches by providing an integrated drought assessment framework covering Austrian cropland at a 1 km grid resolution to (i) quantify the impacts of three drought scenarios in the period 2010-2040 on crop production in Austria, (ii) identify optimal crop production portfolios for drought adaptation considering farmers' risk aversion, and (iii) calculate the economic value of drought information. The assessment framework consists of a statistical climate model, the bio-physical process model EPIC, a crop gross margin calculation script, a portfolio optimization model, and the computation of the economic value of drought information. At national level, average annual dry matter crop yields in optimal crop production portfolios range between 7.6 and 8.0 t/ha, depending on the drought scenario and the level of risk aversion. Average crop gross margins are between 403 and 473 €/ha. Moderate fertilization intensity is the most frequently chosen management practice in the crop production portfolios, regardless of the drought scenario and the risk aversion level. Average annual values of drought information increase with severity of drought scenario and risk aversion but differ by crop production region. The highest values of drought information (above 200 €/ha) are concentrated in the semi-arid eastern parts of Austria and reveal the opportunity costs of lacking this information for crop management choices. The investigations on potential impacts and effective drought adaptation measures may intensify farmers' adaptation efforts and inform water resources management and policies.

Oral Presentation

***Title*: Multiple crop model ensembles for improving broad-scale yield prediction with Bayesian model averaging**

Authors: Xiao Huang[1], G. Huang[1], C. Yu[1], and X. Li[1]
[1] Center for Earth System Science, Key Lab of Earth System Numerical Simulation, Tsinghua University, China

Abstract: Process-based crop models are popular tools to explore the impact of climate change and crop management on crop growth. However, accurate simulation of crop production from single crop model remains challenging over large geographic regions due to different sources of uncertainty. We present the method of Bayesian model average (BMA) for multiple crop-growth model ensembles to provide more reliable predictions of maize yields in Liaoning Province, China, where about 2,200,000 hectares (ha) maize are planted in the 148,000 km2 territory. We apply photosynthesis-oriented WOFOST model, water-orientd AquaCrop model and nitrogen-oriented DNDC model to independently generate the ensemble predictions of the county-level maize yields. The integrated probabilistic prediction is therefore achieved by the linear combination of the three ensembles using the BMA weights. This integrating approach results in an improved accuracy and precision than any single model over the whole region, which demonstrates that the BMA framework effectively compensates the uncertainty of single model simulation and takes advantage of each competing model for reliable prediction. Furthermore, the rationality of the set of BMA weight values is evaluated in comparison with regional precipitation, fertilization and sunshine duration data. We find these values suit well with the regional limiting factor, e.g. AquaCrop model generally obtain high weight value in counties with frequent droughts, while WOFOST is the dominated ensemble in areas with radiation deficit. Compared with simple average method, the results show that the BMA framework is powerful in computing ensemble weights and explaining the mechanism beyond the observed data.

Session 1.1 Seasonal Forecasts and Climate Extremes

1. *Poster Presentation*

Title: **Modelling frost damage in major sugar beet growing area of Khorasan province, Iran**

Authors: Reza Deihimfard[1] and S.R. Moghaddam[1]
[1] Shahid Beheshti University, Iran

Abstract: A simulation study was performed at 8 sites of Khorasan province, in the northeast of Iran where frost damage is one major challenge for a successful cultivation of autumn-winter sugar beet. Accordingly, a modified and validated version of SUCROS model was used to estimate potential yield of sugar beet and frost events over a historical period from 1993 to 2009 under four autumn sowing dates (DOY274, DOY295, DOY314, DOY334) and two spring sowing dates (DOY64 and DOY124). Results indicated that frost damage in autumn sowing dates ranged from 62.5 to 100% at Neyshabour and Ghochan, respectively. According to the cumulative probability distribution of the number of frost events, the highest probability of no frost event obtained at Neyshabor (0.56) and Mashhad (0.5) and the lowest obtained at Bojnord (0.06) and Ghochan (0.0). There was a large variability among sites and years in terms of frost intensity and duration. Minimum temperate reached to -25°C in some years at Mahshad. In contrast, longest frost event occurred at Torbat Jam in 2005 for 39 consecutive days. Although autumn sowing dates showed better performance than spring sowing dates in terms of fresh storage organ yield (~109.9 t ha-1 vs. ~78.4 t ha-1), however, the risk of frost stress under autumn and winter sowing dates are quite high at the all study sites. Accordingly, it is recommended the farmers select an optimum sowing window between February and March during which much lower frost events would be occurred.

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2. *Poster Presentation*

Title: **Impact of extreme events on Russian agriculture**

Authors: Paraskevi Giannakaki[1] and P. Calanca[1]
[1] Agroscope, Institute for Sustainability Sciences, Climate and Air Pollution Control Group, Switzerland

Abstract: Agriculture in Russia is growing fast and the country has become a major grain exporter. This study is focused on the southwestern part of the Russian Federation (Southern, Central and Volga Districts) where the main grain production occurs (wheat, maize and barley). Reliable forecasts of grain yields in the Russian Federation are therefore important in the context of both world food market and food security. For this, the ability to correctly take into account the effects of extreme events is essential, because grain production in Russia has proved to be highly vulnerable to droughts and heat waves over the past years. Moreover, due to climate change the risk of heatwaves is increasing in the area which implies a decrease in grain production.

In this contribution we examine possibilities to monitor the effects of extreme events by means of agroclimatic indicators, which could serve for improving statistical models as well as for the post-processing of dynamical crop model outputs. Daily climate data from 86 weather stations were used to calculate indices of climate extremes under climatic conditions of the recent past (1980-2014). Moreover, a trend analysis of a set of agroclimatic indices for field crop production is performed. This study is part of a new ERA.NET RUS Plus project “Impact of extreme events and climate change on Russian agriculture, economic implication and adaptions”.

Session 1.1 Seasonal Forecasts and Climate Extremes

3. *Poster Presentation*

Title: **Regional assessment of observed, simulated and projected climate over South Punjab**

Authors: Ghulam Rasul[1], B. Ahmad[1], A. Ahmad[2], T. Khaliq[2], and G. Hoogenboom[3]
[1] Pakistan Meteorological Department, Pakistan, [2] University of Agriculture, Faisalabad, Pakistan, [3] Institute for Sustainable Food Systems, University of Florida, USA

Abstract: Extraction of regional climate information from Global Circulation Models (GCMs) require robust selection and integration. Following AgMIP phase II protocols, background daily climate time series (1980-2010) from the AgMERRA datasets are obtained to fill in missing/flagged observation data. Future climate scenarios under two RCPs (4.5 and 8.5) are derived from the latest 29 IPCC climate models and downscaled for use in the target regions. Subsetting of GCMs from 29 to 5 is done based on scatter of mean temperature change and mean precipitation change for the entire growing and harvesting season of cotton-wheat system in South Punjab. Models bearing precipitation projection of not more than 200% are selected. In addition, replication of monsoon in historical climate is also taken into consideration while selecting GCMs. Downscaling of regional climate is done by shifting mean and variability scenarios using the stretched distribution approach that is related to quantile mapping. Post selection and downscaling results under RCP8.5 and CCSM4 model (with cool/dry characteristics) suggest a 2.5°C rise in the maximum and minimum temperatures with 9% decrease in the precipitation amount in the 2040-2069 projected period over the region. The projected increase in temperature and the corresponding decrease in the precipitation regime give clues regarding devastation in the agricultural yield in the 2040-2069 projection period over the region.

Keywords: South Punjab, GCMs, RCPs, AgMERRA, Downscaling, Projections.

Session 1.2 Crop Model Intercomparison

Oral Presentation

***Title*: Inter-comparison of crop models for simulating canola growth and yield**

Authors: Enli Wang[1], D. He[1,2], J. Wang[2], B. Christy[3], M. Hoffmann[4], J. Lilley[1], G. O'Leary[3], J. Hatfield[5], L. Ledda[6], P. A. Deligios[6], B. Grant[7], Q. Jing[7], H. Kage[8], B. Qian[7], E. E. Rezaei[9], W. Smith[7], W. Weymann[8], and The AgMIP-Canola Team

Abstract: The first comprehensive study on inter-comparison of crop models for simulating growth and grain yield of canola crop has been completed by the AgMIP-Canola team. The team was formed in 2015 and is now finalizing its phase I work and result analysis. The main focus of AgMIP-Canola Phase I was inter-comparison of the major canola models against multiple datasets and analysis of the sensitivity of simulation results to different scenarios of climatic and management changes. Fifteen modelers in 5 countries (Australia, China, Canada, Germany, and Italy) participated with eight crop models (APSIM, CAT-Canola, DSSAT, DayCent, DNDC, HUME, MONICA, SIMPLACE). Experimental data from 6 sites across 5 countries (Australia, China, Germany, Italy and USA) were used to compare model performances. Sensitivity analysis was carried out with a combination of 5 levels of atmospheric CO_2 concentrations, 7 temperature changes, 5 precipitation changes, together with 5 N application rates. Preliminary results showed that a partial model calibration (only for phenology) led to poor simulation of biomass and yield, and even the ensemble mean/median differed significantly from measurements across sites. A full calibration with additional data of LAI, biomass and yield from one treatment each site significantly improved model performance for biomass and yield simulations. The multi-model ensemble median yield was better than single-model yield predictions for some but not all models. Results from the sensitivity simulations and the differences in model performances are being analyzed to identify knowledge gaps and new datasets for the model improvement in the next phase.

Oral Presentation

***Title:* Lessons Learned from Evaluating APSIM and DSSAT Maize Model Responses to Carbon Dioxide, Temperature, Water, and Nitrogen.**

Authors: Kenneth Boote[1], C. Porter[1], J. W. Jones[1], J. Dimes[2], J. Hargreaves[2], P. Thorburn[2], D. MacCarthy[3], P. Traore[3], W. Durand[4], D. Cammarano[4], P. Masikati[5], S. Homann[5], S. Gummadi[6], L. Claessen[6], D. Murthy[7], G. Vellingiri[7], S. P. McDermid[8], and A. C. Ruane[9]
[1] University of Florida, USA, [2] CSIRO, [3] CIWARA, [4] SAAMIP, [5] CLIPS, [6] E. Africa, [7] S. India, [8] New York University, USA, [9] NASA GISS, USA

Abstract: It is important, in climatic impact assessment, to understand how different crop models respond to CO_2, temperature, rainfall, and nitrogen (CTWN). Regional teams in West Africa, East Africa, South Africa, Southeast Africa, and South India obtained farm survey yield data for maize from households in their regions, along with farmer management information, historical weather, soils, and local cultivar calibrations. They selected a representative farm for evaluating DSSAT and APSIM maize model simulations for response to CTWN. Simulated response to N fertilization from 0 to 180 kg N ha-1showed that stable or inert soil C pools for the models had to be set correctly to mimic the yields obtained for zero N fertilizer (or farmer observed yields), and that the yields at high N fertilization represent the genetic potential of the cultivar. The need for correct N response is very important because the teams want to use N fertilization as an option for improving production. The two maize models had a very modest response to CO_2 that was less at low N. Increasing temperature reduced yield for both models at most sites, with DSSAT being more sensitive at high temperature. Response to rainfall was less than expected for West and East Africa, because N was so limiting that the low LAI created low transpiration demand. In South and Southeast Africa, where rainfall was lower, the sensitivity to rainfall was stronger, with greater yield reductions for DSSAT than for APSIM. The CTWN exercise was valuable for understanding differential model sensitivity to climatic factors, and guiding model calibration for response to N fertilization for degraded soil conditions.

Session 1.2 Crop Model Intercomparison

Oral Presentation

Title: **Who has the 'best' crop model?**

Authors: Senthold Asseng, P. Martre, F. Ewert, D. Wallach, B. Liu & AgMIP-Wheat team

Abstract: Who has the 'best' crop model? Nobody has! – as no 'best' crop model exists so far. Multi-model intercomparisons of many different crop models with field observations have shown that there is no single model 'best' suited across different growing conditions. There is also no particular model approach for specific processes (e.g. for photosynthesis) superior across growing conditions. Multi-model intercomparisons showed that while some crop models might reproduce field data very well in one environment, there are different models better in reproducing field data in other environments. Disregarding a crop model based on a few observations might also be premature as such a model might perform very well in other conditions. However, the multi-model ensemble median of crop models has been repeatedly proven as a superior predictor of observed data across different growing conditions (and across crops), compared with any single model. The required number of models in an ensemble for the ensemble median to be a better predictor than any individual model could be as small as 2-5, depending on the growing environment. Comparing simulated impacts from multi-model ensembles with other methods, like statistical methods of impact assessment further supports the validity of a multi-model ensemble approach. Recent progress in AgMIP-Wheat and AgMIP-Wheat linked to other themes in AgMIP will be discussed.

Oral Presentation

Title: **Global Gridded Crop Model evaluation: benchmarking, skills, deficiencies and implications**

Authors: Christoph Müller[1], J. Elliott[2], and GGCMI phase 1 modeling team
[1] PIK, Germany, [2] University of Chicago, USA

Abstract: Large differences between global-scale and also between field-scale crop models have been recently reported, following a general call to revisit modeling skills and approaches. For this central objective of AgMIP and ISI-MIP 14 global gridded crop models (GGCMs) have contributed simulations of the historic past (1901-2012) in the framework of AgMIP's GGCM Intercomprison project.

The global scale is especially challenging for model application and evaluation because of the vast climatic and managerial differences between regions but also because of the limited availability of reference data at sufficient detail and a general difficulty in comparing results of global-scale simulations with site-specific data. Global scale models need to be evaluated at the scale of application, which is typically national or regional aggregates, but site specific data can provide better insights on how well general mechanisms in plant growth and yield formation are represented in the models.

We here provide a broad model evaluation framework to test performance of GGCMs and also to identify general and individual model deficiencies across different crops and regions. Model skill is evaluated for the four major crops wheat, maize, rice and soy. We find that GGCMs have substantial skill in reproducing spatial and temporal patterns of yield productivity at the global scale and within individual regions, but that individual models can have complimentary skills, suggesting large potentials for within-ensemble learning. These findings will serve as a basis for further model development and improvement.

Session 1.2 Crop Model Intercomparison

Oral Presentation

***Title*: The uncertainty cross-cutting theme**

Authors: Daniel Wallach[1], L. Mearns[2], P. Thorburn[3], R. Rotter[4], A.C. Ruane[5], S. Asseng[6], A. Challinor[7], J. Jones[6], and F. Ewert[8]
[1] INRA, France, [2] NCAR, [3] CSIRO, [4] University of Göttingen, Germany, [5] NASA GISS, USA, [6] University of Florida, USA, [7] University of Leeds, UK, [8] University of Bonn, Germany

Abstract: This is a report on recent and planned activities of the uncertainty cross-cutting theme, which aims at developing, analyzing and diffusing effective methods of estimating the uncertainty in model predictions. A study on the lessons from the climate modeling community on the design and use of ensembles for crop modeling was led by a crop modeler and a climate modeler. This is meant to serve as a roadmap for future methodological studies on ensemble crop modeling. It covers questions related to the creation of ensembles, model weighting within ensembles, single model ensembles, super ensembles, uncertainty evaluation based on ensembles and the use of the ensemble to create better predictors. A study on model evaluation showed that there are two different viewpoints about model evaluation, depending on whether the model is treated as fixed or random. In both cases mean squared error of prediction (MSEP) is a useful criterion of model prediction uncertainty, but the interpretation and estimation are very different in the two cases. A study on the effect of averaging a quantity of interest over space or time on uncertainty showed that averaging always reduces MSEP, and that the amount of reduction can be estimated given hindcasts that are relevant to the averaging process. A new activity, now being organized, concerns crop model calibration. The objective is to document current methods and propose guidelines for improved methods, which will be tested by multiple models on common data. This activity is open to those interested.

Oral Presentation

***Title:* Parameterization induced uncertainty of the EPIC model to estimate climate change impact on global maize yield**

Authors: Wei Xiong, R. Skalský, C. H. Porter, J. Balkovič, J. W. Jones, and Y. He
[1] Institute of Environment and Sustainable Development in Agriculture, Chinese Academy of Agricultural Sciences, [2] Department of Agricultural and Biological Engineering, University of Florida, [3] International Institute of Applied Systems Analysis (IIASA), Ecosystem Services and Management Program, [4] Soil Science and Conservatio Research Institute, [5] Faculty of Natural Science,Comenius University in Bratislav

Abstract: Understanding the interactions between agricultural production and climate is necessary for sound decision-making in climate policy. Gridded and high-resolution crop simulation has emerged as a useful tool for building this understanding. Large uncertainty exists in this utilization, obstructing its capacity as a tool to devise adaptation strategies. Increasing focus has been given to sources of uncertainties for climate scenarios, input-data, and model, but uncertainty due to model parameterization are still unknown. Here, we use publicly available geographical datasets as input to the Environmental Policy Integrated Climate model (EPIC) for simulating global gridded maize yield. Impacts of climate change are assessed up to the year 2099 under a climate scenario generated by HadEM2-ES under RCP 8.5. We apply five parameterization strategies by shifting one specific parameter in each simulation to calibrate the model and understand the effects of parameterization. Regionalizing crop phenology or harvest index appears effective to calibrate the model for the globe, but using various values of phenology generate pronounced difference in estimated climate impact. However, projected impacts of climate change on global maize production are consistently negative regardless of the parameter being adjusted. Model parameterization results in a modest uncertainty at global level, with spread of the global yield change less than 30% by the 2080s. The uncertainty is likely to increase if parameterizing multiple parameters simultaneously that often being practiced in site specific simulations. Parameterization has a larger effect at local scales, implying the possible types and locations for adaptation.

Session 1.2 Crop Model Intercomparison

4. *Poster Presentation*

Title: **Comparative analysis of the simulation of canola phenology from biophysical modules at selected field sites across Canada**

Authors: Aston Chipanshi [1], Y. Zhang[2], G. Bourgeois[3], B. Qian[2] and B. Bondaruk[2]
[1] Science & Technology Branch, AAFC, Saskatchewan, Canada, [2] Science & Technology Branch, AAFC, Ottawa, Ontario, Canada, [3] Science & Technology Branch, AAFC, Québec, Canada.

Abstract: We evaluated the commonly used cereal based temperature phenology models with the goal of adapting one for canola so that it can be integrated into near real time monitoring of crop conditions and crop yield estimates. Using field data collected from sites across Canada, a comparative analysis of canola crop stages as calculated from a simple algorithm using growing-degree-day (GDD) accumulation, a module from the Computer Centre for Agricultural Pest Forecasting (CIPRA) and the CROP GRO model were compared with the field observed stages. Field observations were recorded using the BBCH scale and complemented by leaf area index (LAI) and above ground total biomass. Supporting data- the daily maximum and minimum temperature, total precipitation and solar radiation (at some sites) as well soil moisture were measured. Field nutrient data (N, P, K and S) were also collected.

Between the CIPRA and CROP GROW simulations, there was little difference in the simulated onset of budding, flowering, pod setting and ripening in relation to the observed dates. Even though the CROP GRO simulated dates were within the range of the CIPRA simulated values, it was difficult to ascertain some of the crop and environmental parameters inputs required to arrive at the simulated dates in CROP GROW. Likewise, while the GDD-based simulated stages were broadly comparable to the CIPRA and CROP GROW values, the canola parameters were first estimated from published sources. Results from the CIPRA method were found suitable for integration into the canola statistical yield prediction model.

KEYWORDS: Phenology, canola, growing-degree-day, CIPRA, CROP GROW.

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5. *Poster Presentation*

Title: **Geospatial crop simulation scheme to deliver amendment measures to alleviate the impact of climate change on crops**

Authors: Jonghan Ko, S. Jeong, and J. Choi
Chonnam National University, South Korea

Abstract: Determining effective measures that can be used to alleviate the impacts of climate change on crops is one of the most urgent issues facing agriculture. Accordingly, our objectives in this study were (1) to develop a geospatial crop simulation modeling (GCSM) system to simulate regional crop production data and (2) to determine the current and future remedial measures using the developed simulation design. We formulated the GCSM scheme using the Decision Support System for Agricultural Technology (DSSAT) crop model package version 4.6, in which crop models can be used to conduct numerous pixel data runs based on shell scripting in a Linux operating system. The developed GCSM system was verified by its capability to simulate barley (Hordeum vulgare) production in South Korea, and the GCSM was then used to simulate the effects of climate change on barley production for the same geographical region. Therefore, we will be able to use the GCSM to investigate and report potential remedial measures that can be used to amend or alleviate the potential future impacts of climate change on barley production. Although the current GCSM system requires further development to formulate more concrete tools for agricultural scientists, farming business managers, and stake holders, we believe that the system could be effectively used to simulate geospatial variations of climate change impacts on crops and to search for potential solutions to the impending food insecurity.

Session 1.2 Crop Model Intercomparison

6. *Poster Presentation*

Title: **Ozone changes the photosynthesis-conductance relationship for Rice**

Authors: Yuji Masutomi[1], T. Yonekura[2], T. Takimoto[3],and H. Oue[4]
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Abstract: Ozone (O3) is one of significant factors reducing crop yields. To date, the reduction of crop yields due to O3 has been assessed by the dose-response models and, more recently, the fluxed-based models. These models, however, can't quantify the combined effect of O3 and other important factors that affect crop yields, e.g., climate change and the increase in CO_2 concentration. One useful approach for quantifying the combined effect is to incorporate the O3 impact into a photosynthesis-conductance model, e.g., the Farquhar/Ball-Woodrow-Berry (BWB) model. However, fundamental understanding of the O3 impact on the photosynthesis-conductance models for crops is still missing. For example, nothing is known about the influence of O3 on the BWB relation for crops. The objective of this study is to reveal whether O3 has influence on the BWB relation for rice. To achieve the goal, we grew 4 rice varieties under ambient and elevated O3 concentration in 2008 in China using FACE system. The comparison of the observed BWB relations under ambient and elevated O3 conditions revealed that increase in O3 can change the BWB relation for rice. But there was large difference in the changes of the BWB relation among rice varieties. These results imply that the change of the BWB relation due to O3 and the difference in the change among rice varieties should be considered when we assess the risk of ozone for rice.

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7. *Poster Presentation*

Title: **Generation of crop model ensembles by use of a modelling framework**

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Abstract: We present an example for the generation of model ensembles by use of the model framework Expert-N. Different crop models are obtained by choosing different sub-models which represent important processes to determine the dynamics of crop growth. In this way different sub-models to simulate potential evapotranspiration, actual evaporation, actual transpiration, soil water flow, soil nitrogen transport, soil carbon and nitrogen turnover, crop development, canopy photosynthesis, potential and actual nitrogen uptake and crop growth are combined resulting in different crop models making up an ensemble of crop models. The sub-models are based on process descriptions that are included in the crop models CERES, SUCROS, SPASS and GECROS, but also stem from known soil models such as CENTURY, SOIL, SOILN, NCSOIL, LEACHM or HYDRUS.

The generated model ensemble is applied to simulate winter wheat growth at a field site in Southern Germany. Simulation results are compared to measurements of crop biomass and yields and to soil water and nitrogen contents. It is concluded that model frameworks as the model system Expert-N can help to analyse structural uncertainties that lead to different simulation results between models of a model ensemble.

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Priesack, E., Gayler, S., Hartmann, H.P.: The impact of crop growth sub-model choice on simulated water and nitrogen balances. Nutr. Cycl. Agroecosys. 75 (2006) 1-13.

Session 1.2 Crop Model Intercomparison

8. *Poster Presentation*

Title: **Multi-wheat-model ensemble responses to interannual climate variability**

Authors: Alex C. Ruane[1], N. I. Hudson[2], S. Asseng[3], D. Camarrano[3,4], F. Ewert[5, 21], P. Martre[6], K. J. Boote[3], P. J. Thorburn[7], P.K. Aggarwal[8], C. Angulo[5], B. Basso[9], P. Bertuzzi[6], C. Biernath[10], N. Brisson[6,11], A. J. Challinor[12,13], J. Doltra[14], S. Gayler[15], R. Goldberg[2], R.F.Grant[16], L. Heng[17], J. Hooker[18], L.A. Hunt[19], J. Ingwersen[15], R. C. Izaurralde[20], K.C. Kersebaum[21], S. N. Kumar[22], C. Müller[23], C. Nendel[21], G. O'Leary[24], J. E. Olesen[25], T. M. Osborne[18], T. Palosuo[26], E. Priesack[10], D. Ripoche[6], R. P. Rötter[26,34], M. A. Semenov[27], I. Scherbak[28], P. Steduto[29], C. O. Stöckle[30], P. Stratonovich[27], T. Streck[15], I. Supit[31], F. Tao[26,31], M. Travasso[32], K. Waha[23,8], D. Wallach[6], J. W. White[33], and J. Wolf [31]

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Abstract: We compare 27 wheat models' yield responses to interannual climate variability, analyzed at locations in Argentina, Australia, India, and The Netherlands as part of the Agricultural Model Intercomparison and Improvement Project (AgMIP) Wheat Pilot. Each model simulated 1981–2010 grain yield, and we evaluate results against the interannual variability of growing season temperature, precipitation, and solar radiation. The amount of information used for calibration has only a minor effect on most models' climate response, and even small multi-model ensembles prove beneficial. Wheat model clusters reveal common characteristics of yield response to climate; however models rarely share the same cluster at all four sites indicating substantial independence. Only a weak relationship ($R2 \leq 0.24$) was found between the models' sensitivities to interannual temperature variability and their response to long-term warming, suggesting that additional processes differentiate climate change impacts from observed climate variability analogs and motivating continuing analysis and model development efforts.

Session 1.2 Crop Model Intercomparison

9. *Poster Presentation*

Title: **CTWN – Carbon-Temperature-Water-Nitrogen responses of DSSAT and APSIM models in relation to crop management and initial soil conditions in wheat**

Authors: Nataraja Subash[1], K. J. Boote[2], P. L. Paulton[3], B. Singh[4], C. Porter[2], S. P. McDermid[5], H. Singh[1] and G. A. Baigorria[6]

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Abstract: Crop models are extensively used for assessing the impact of climate change and projecting the food security scenario of important food crops at local to global level. Even though these models are basically evolves the crop growth and development around growing degree concept, however, several subroutines with model specific processes, depending on the researchers/developers field of specialization and location of model influences the simulation results. Here under Agricultural Model Intercomparison and Improvement Project (AgMIP), we systematically created the CTWN (Carbon, Temperature, Water & Nitrogen) sensitivity simulation set up in APSIM-wheat and DSSAT-wheat to compare the responses of these models to changes in these variables. The analysis is done for 76 farm sites, with the C,T,W &N variables changed one at a time so that responses can be compared without interactions and so outputs can be analyzed in detail where model responses differ. The standard CTWN protocol includes the following 32 simulations: CO_2 – 360, 450, 540, 630, 720ppm (run for 30 kg/ha N and 180 kg/ha N) - 10 simulations; Tmax/Tmin - -2, 0, +2, +4, +6, +8 oC – 6 simulations; Rainfall – 25%, 50%, 75%, 100%, 125%, 150%, 175%, 200% - 8 simulations; Fertilizer N – 0, 30, 60, 90, 120, 150, 180, 210 kg/ha – 8 simulations. The sensitivity of APSIM and DSSAT is different for CO_2, temperature and fertilizers, even though both are showing the same trend. Similarly, it is also found that the initial soil conditions, crop management conditions influences the model sensitivity to CTWN. Therefore, clear understanding of the model processes is very much essential for applications of these models for projecting the impact of climate change on yield as well as to address food security issues under future projected climate change.

Session 1.3 Developing Adaptation Strategies

Oral Presentation

Title: **Developing adaptation packages for West African agriculture while ensuring congruence with climate and RAPs.**

Authors: Ibrahima Hathie[1], D.S. MacCarthy[2], S. B. Freduah[2], A. Nenkam, M. Adams, G. K. Adiku[2], P.C.S. Traore[3], J. Clottey[2], A. Ly[1], and S. Narh[2]
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Abstract: In the semi-arid region of the Sahel, climate change is already affecting the farming systems and these impacts are expected to heighten in the near to mid-century. Given the complexities and conflicting drivers at play and the foreseeable negative consequences on the livelihoods of the majority of farmers, it is worthwhile designing relevant adaptation packages that will alleviate these effects. In this study, we envision to assess the implications of implementing two adaptation packages within the context of three West African farming systems specifically located in Ghana (Navrongo), Mali (Koutiala) and Senegal (Nioro). The first adaptation package is composed of heat and drought tolerant species along with an economic and policy level intervention through the delivery of subsidies to acquire improved varieties. The second pack builds on the first but adds a fertilizer component (splitting and timing to account for extreme events) and a policy variable in the form of index-based insurance adoption. The design process included interactions with a diverse set of stakeholders. The outcomes of these adaptation options on current and future agricultural systems will shed light on the projected adoption rates of climate adapted-systems and show how these various adaptations affect the impacts of climate change, keeping congruence with the relevant representative agricultural pathways.

Oral Presentation

Title**: Designing and Assessing Adaptation Strategies to Face Challenges of Climate Change: Insights from Indo-Gangetic Plains of India**

Authors: Harbir Singh[1], N. Subash[1], G. Paudel[2], B. Singh[3], R. Valdivia[4,] and G. Baigorria[5]
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Abstract: The adverse impacts of climate change are clearly discernable particularly in South Asia with greater variability of monsoon and an increase in the occurrence of extreme weather events such as droughts, floods and intense heat waves. The Indo-Gangetic basin (IGB), which is characterized by smallholder agriculture, is highly vulnerable to climate change. This region is considered the rice-wheat bowl of the country, In addition to food requirements, more than half of the rural population is dependent on agriculture for earning its livelihood. With the growing challenges to provide food security for rising populations, it is pertinent to identify and test suitable adaptation strategies not only for the existing production systems but also for the future farming systems. The Agricultural Model Improvement and Intercomparison Project (AgMIP) has developed protocols which help in designing and testing adaptation strategies to deal with climate change. Primarily this study is aimed at designing adaptation strategies across four locations in the IGB. Two locations in North-West India (Meerut and Karnal) have highly intensive farming system which is showing signs of stagnation with overexploitation of natural resources. The other two locations in the North-East India (Faizabad and Samastipur) have under-utilized productivity potential. The adaptation strategies for these two distinct production environments are expected to be different considering their specific production environments and socioeconomic settings. This presentation will share experiences of designing adaptation strategies for two locations in North-West India (Meerut and Karnal) and demonstrate their use in dealing with adverse impacts of climate change.

Session 1.3 Developing Adaptation Strategies

Oral Presentation

***Title*: Exploring adaptations to variable and changing climates for smallholder mixed crop livestock systems in semi-arid Zimbabwe**

Authors: Sabine Homann-Kee Tui[1], P. Masikati[2], K. Descheemaeker[3], G. Sisito[4], B. Francis[5], T. Senda[4], O. Crespo[6], H. Mlilo[1], D. Nyoni[7], and E. Moyo[8]
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Abstract: Smallholder farmers in semi-arid Zimbabwe are on a challenging journey, levels of vulnerability are high. Interplay variable and changing climate, inherently poor soils, weak input and knowledge support systems and non-functional markets impact productivity and food security, and keep these systems at a stuck state of poverty. Co-designing desirable futures with farmers and other stakeholders is a powerful way to illustrate possible pathways and gains from adaptations. Here we share the process of developing adaptation options for Nkayi district in semi-arid Zimbabwe: 1. Systems conceptualization: Participatory visioning at community scale informed current and desired systems states, and adaptation options designed for different farm types, grounded in context and identity. Representative Agricultural Pathways (RAPS) were assessed at provincial scale illustrating possible future trends. 2. Adaptation to current climate: The effects of currently promoted practices and technologies, crop livestock intensification using low risk soil fertility management combined with livestock feeding, proved insufficient for improving smallholder livelihoods. Hence more transformative adaptation options were tested, with greater diversification into food, feed and cash legumes. 3. Adaptation to future climate: Switching to drought tolerant varieties was tested for different farming futures, towards sustainable intensification versus economic growth and resource extraction. 4. Stakeholder feedback: Modeling outputs on technology impacts fed the discussion among researchers and stakeholders on how adaptations can become realistic for current conditions and adjusted for future climate and socio-economic conditions. This can inform options for reducing risk and vulnerability, windows of opportunities, policy and institutional implications.

Oral Presentation

***Title:* Integrated assessments in Irrigated Agriculture linking Crop and Hydrological Models : The case of Central Chile**

Authors: Francisco J. Meza, L. Henriquez, D. Poblete, and S. Vicuña
Centro de Cambio Global. Pontificia Universidad Catolica de Chile

Abstract: As a consequence of population growth, increasing competition for water resources and changes in temperature, precipitation, and runoff, irrigated agriculture will be one of the most affected sectors, particularly in Mediterranean regions.

In these regions, agriculture develops a two way interaction with surface water resources because the nature of irrigation systems (i.e. rate of withdrawals and efficiency of use) determines the real demand and availability for agricultural systems downstream.

The search for feasible adaptation strategies requires the use of integrated models that combine the scenarios of land use and climate change, hydrological responses at the basin level, and an evaluation of crop water use and yields, particularly under restricted conditions.

In this work we present a case study for one of the most important basins of central Chile (the Maipo Basin). We use the Water Evaluation and Planning model (WEAP) coupled with a Crop Simulation model to assess the potential impacts of climate change for irrigated agriculture (the most important consumer of surface water resources in the basin).

A set of adaptation strategies, that involve basin regulation, a market of water use rights, changes in irrigation systems are evaluated using water security metrics.

Session 1.3 Developing Adaptation Strategies

Oral Presentation

***Title*: Developing and Assessing Adaptation Strategies against climate vulnerability in cotton wheat cropping system of Punjab, Pakistan**

Authors: Muhammad Ashfaq[1], J. Nasir[1], I.A. Baiq[2], and I. A. Chattha[1]
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Abstract: This is a part of session on "Designing and Assessing Adaptation Strategies".

Agricultural production systems are complex, interlinked and dependent on various factors. Crop production is climate prone sector of the economy. Anticipation and adaptations to climate change is important tool. There are certain planned and unplanned adaptations regarding climate vulnerability in agricultural systems that maintain the balance in ecosystem and minimize the economic losses. To minimize the climate losses there can be adaptation strategies on farm/regional and national level. To access the benefits of adaptations AgMIP-Pakistan formulated the adaptation packages through continuous engagement process with researchers, farmers and policy makers to combat the current and future climatic vulnerabilities.

Various sessions were organized for the expert opinion regarding designing adaptation strategies and assessing their socio-economic impacts. Second meeting was held with progressive farmers at field for practical field issues and adaptation measures. Wide range of adaptation strategies were shared by team members and got the feedback from stakeholders on every aspect. For current and future climatic vulnerabilities different short term and long term adaptation strategies were compiled in which biophysical, socioeconomic and policy parameters were assessed. Important adaptation parameters for future were genetic improvements, draught resistant and heat tolerant varieties, deep tillage, soil and water conservation practices, construction of water storage, efficient irrigation systems, crop diversification, agricultural insurance and farm mechanization. For current adaptations, increase in plant population, fertigation, efficient irrigation and import of improved gene cultivar were important ones. The adaptation package was shared with crop modelers for their input. The great challenge was to incorporate those parameters which could be used in the modelling.

Oral Presentation

***Title*: Incremental crop management adaptations to climate change: an integrated assessment for European agriculture**

Authors: Heidi Webber[1], A. Zimmermann[1], G. Zhao[2], W. de Vries[3], J. Kros[3], J. Wolf[4], and F. Ewert[1]
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Abstract: Farmers are expected to make incremental adaptations in crop management, such as adapting sowing dates and changing varieties in response to gradually warming temperatures. This study aims to quantify the importance of such adaptations for European agriculture, considering crop yields, prices, production level, land use and nitrogen losses to the environment. An integrated modelling framework was used, consisting of the crop model SIMPLACE<Lintul-5, DRUNIR, Heat>, the economic agricultural sector model CAPRI and the environmental model INTEGRATOR. The study considered agricultural changes in the EU-27 under three SRES scenarios for 2050. SIMPLACE simulated water-limited growth of seven crops in response to climate and CO_2 concentration to determine relative yield changes for no adaptation, optimal adaptation and a non-optimal "actual" adaptation scenario. To simulate changes in European agricultural markets (land use, supply, demand, and prices) with CAPRI, historical yield trends were extrapolated for each scenario to give relative yield changes due to climate, adaptation and technology progress for each of the three adaptation cases together with scenario specific changes in global gross domestic product, population, and agricultural trade policies. The results of changed land use and yield drive agricultural emissions calculated by INTEGRATOR. Results indicate that the method of specifying adaptations had a very large influence on projected yields under climate change, though assumptions about technology progress appear to have a larger influence for all indicator variables. Challenges in specifying crop management in integrated assessments are highlighted and ways to address these are discussed.

Session 1.3 Developing Adaptation Strategies

10. *Poster Presentation*

Title: **Exploring the adaptation scope – optimization-based decision-support for transformative adaptation planning**

Author: Annelie Holzkämper[1]
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Abstract: Climate change implies changes in agricultural plant production conditions, which can be either negative or positive. To maintain or even increase productivity – making use of emerging potentials – management adaptations are inevitable. Contrary to short-term incremental adaptation, which is often implemented by local farmers autonomously, long-term transformative adaptation planning requires greater anticipation. In that respect, predictive impact models are valuable tools to estimate changes in climatic limitations to crop growth. The identification of adequate responses to such impacts can be a challenging task given that particular adaptation choices can affect various other agroecosystem services besides production (e.g. soil retention, water provision). Integrated assessments of climate change impacts and adaptation options are essential for anticipating long-term effects on various agroecosystem services and thus for reducing the risk of maladaptation.

This contribution demonstrates the potentials of multi-objective optimization for decision-support in transformative adaptation planning. Case study results are presented, showing Pareto-optimal adaptation strategies with regard to different adaptation goals (i.e. maximum productivity, minimum erosion, minimum leaching) and evaluating their robustness to potential sources of uncertainty. Model results allow for a quantification of maladaptation risks, thus helping to direct precautionary management efforts.

Session 1.4 Climate Change Assessments

Oral Presentation

***Title*: Regional disparities in the beneficial effects of rising CO_2 concentrations on crop water productivity**

Authors: Delphine Deryng[1], J. Elliott[2], C. Folberth[2], C. Müller[3], T. A. M. Pugh[4], K. J. Boote[5], D. Conway[6], A. C. Ruane[7], Dieter Gerten[3], J. W. Jones[5], N. Khabarov[2], S. Olin[8], S. Schaphoff[3], E. Schmid[9], H. Yang[10], and C. Rosenzweig[7]
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Abstract: Rising atmospheric CO_2 concentrations ($[CO_2]$) are expected to enhance photosynthesis and reduce crop water use. However, there is high uncertainty about the global implications of these effects for future crop production and agricultural water requirements under climate change. Here we combine results from networks of field experiments and global crop models to present a spatially explicit global perspective on crop water productivity (CWP, the ratio of crop yield to evapotranspiration) for wheat, maize, rice and soybean under elevated $[CO_2]$ and associated climate change projected for a high-end greenhouse gas emissions scenario. We find CO_2 effects increase global CWP by 10[0;47]%–27[7;37]% (median[interquartile range] across the model ensemble) by the 2080s depending on crop types, with particularly large increases in arid regions (by up to 48[25;56]% for rainfed wheat). If realized in the fields, the effects of elevated $[CO_2]$ could considerably mitigate global yield losses whilst reducing agricultural consumptive water use (4–17%). We identify regional disparities driven by differences in growing conditions across agro-ecosystems that could have implications for increasing food production without compromising water security. Finally, our results demonstrate the need to expand field experiments and encourage greater consistency in modelling the effects of rising $[CO_2]$ across crop and hydrological modelling communities.

Oral Presentation

***Title:* Impacts of soil data uncertainty on crop yield estimates in a global gridded crop model**

Authors: Christian Folberth[1], R. Skalský[2], E. Moltchanova[2], J. Balkovič[2], L. B. Azevedo[2], M. Obersteiner[2], and M. van der Velde[3]
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Abstract: Global gridded crop models (GGCMs) are frequently used for assessments of climate change impacts on crop yields and externalities of agricultural production. Whereas the influence of climate data and projections from general circulation models on GGCM simulations has frequently been investigated in the past, the influence of soil data has so far been neglected at the global scale. However, recently compiled global soil datasets such as the Harmonized World Soil Database usually provide various soil types for each grid cell globally, of which usually only the most dominant one is taken into account in GGCM simulations. As cropland is often scattered and very specific soils may be cultivated in a certain region, the most dominant soil may however not be representative for a specific grid. Comparing yield variability caused by selecting all possible soils in each grid for a GGCM simulation to weather-induced yield variability shows that without fertilizer application, yield variability related to soil types generally outweighs the simulated inter-annual variability due to weather. At increasing fertilizer application rates and with sufficient irrigation this variability is reduced until it is negligible. Estimated climate change impacts on maize yields for a business as usual crop management scenario resulted in either negative or positive yield changes depending on the chosen soil type. This highlights soils' capacity to either buffer or amplify climate and weather effects. The findings call for improvements in soil data for crop modelling, the spatial allocation of cropland and soil types and more explicit accounting for soil variability in GGCM simulations.

Session 1.4 Climate Change Assessments

Oral Presentation

Title: **An integrated assessment of climate change impacts and adaptation in smallholder crop-livestock systems in Kenya**

Authors: Lieven Claessens[1], S. Gummadi[2], M. Kilavi[3], A. Oyoo[1], J. Recha[4], C. Mwongera[5], K. Shikuku[5], C. Dickson[6], R. Valdivia[6], J. Antle[6]
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Abstract: Agriculture in Sub-Saharan Africa is expected to experience considerable negative impacts of climate change. Smallholder mixed crop-livestock systems are particularly vulnerable and need to adapt to sustain or improve productivity, food and nutritional security and livelihoods. Addressing adaptation in this context raises special challenges that call for an integrated, system-based approach to inform decision and policy making. This paper applies the latest methodologies and protocols of the AgMIP Regional Integrated Assessment framework to three agro-ecologies with maize-based crop-livestock systems across Kenya. The approach uses the Tradeoff Analysis model for Multi-Dimensional impact assessment (TOA-MD), which ex ante simulates impacts of climate change and adaptation with associated economic, environmental and social outcomes. Characteristics of current and future agricultural systems, including land use, output and cost of production, are analyzed and compared for both current and projected future climate. The current agricultural systems are characterized based on a household survey of 1162 households. Crop models are used to simulate impacts of climate change and adaptation on productivity. Other components of the (potentially) adapted system are parameterized based on experimental data and/or elaborated from stakeholder consultations. We also make use of socio-economic scenarios (Representative Agricultural Pathways) to answer four core questions: (i) What is the sensitivity of current agricultural production systems to climate change? (ii) What are the benefits of adaptation in current agricultural systems? (iii) What is the impact of climate change on future agricultural systems? (iv) What are the benefits of climate change adaptations? This paper presents the first results from Kenya and discusses the challenges researchers face with performing integrated assessments in the context of complex smallholder crop-livestock systems in SSA.

Oral Presentation

Title: **Towards a 21st Century Climate Service for small-holder farmers in Zimbabwe: Definition of the climate problem**

Authors: Elisha N. Moyo[1,2], F.T. Mugabe[1], M. R. Ndebele-Murisa[1] and A. Makarau[3]
[1] Chinhoyi University of Technology, Chinhoyi, Zimbabwe, [2] Climate Change Management Department – Ministry of Environment, Water and Climate, Harare, Zimbabwe, [3] Meteorological Services Department, Harare, Zimbabwe

Abstract: In order to build the resilience of smallholder farmers and design a 21st century Climate Service for such communities, it is critical to first establish the climate problem in the target area. The study investigates some of the weather and climate challenges in Midlands and Masvingo Provinces of Zimbabwe and possible implications on the suitability of rain-fed maize production and livelihoods. Using both quantitative and qualitative data collection methods, the authors investigates the observed climate dynamics in the three districts and compares them with the farmers' perceptions. Farmers' understanding of- and ability to use weather and climate products and services in agricultural production and other forms of livelihoods were also assessed.

Results show that farmers have observed changes in weather patterns and climate. The climate analyses ascertained comparability of observed historical trends in climate farmers' perceptions across the three districts. They however have limited knowledge of the causes of the causes of the changes, the communities are fully aware of their levels of vulnerability and the impact of these weather and climate changes. They are also aware of their current and future adaptation needs which include: accurate and tailored (area-specific) weather and climate information; relevant extension services (in line with changing weather and climate patterns); options for diversifying livelihoods as well as innovations and appropriate technologies to respond to the weather and climate-related problems Their knowledge of the corresponding impacts in the near-future, required services and products for effective climate resilience in the 21st century could still be improved.

Session 1.4 Climate Change Assessments

Oral Presentation

Title: **Economic Analysis of Climate Impact and Adaptation for the Dryland Wheat System in the US Pacific Northwest**

Authors: Hongliang Zhang[1], J. Antle[1], J. Mu[1], C. Stockle[2], and J. Abatzgolou[3]
[1] Department of Applied Economics, Oregon State University, USA, [2] Department of Biological Systems Engineering, Washington State University, USA, [3] Department of Geography, University of Idaho, USA

Abstract: The US Pacific Northwest possesses some of the most productive dryland grain-producing soils in the world, producing 13% of the nation's wheat supply and 80% of its specialty soft white wheat. The long-term sustainability of agriculture in this region could be threatened by changes in future climate and socio-economic conditions and thus critically depends on available adaptions to these changes. This study applied the AgMIP Regional Integrated Assessment method to assess the economic impacts of climate change on the dryland wheat production system in the US Pacific Northwest and likely changes in existing cropping systems in response to climate and plausible changes in socio-economic conditions, using downscaled climate data, site-specific crop simulations, and detailed economic data. Results show that climate change by 2050 will increase average crop productivity and economic net returns for the wheat production system on average in this region under most Global Climate Models, with or without changes in socio-economic conditions. But the economic impacts are not uniformly distributed among farms, and due to this heterogeneity, some gain and some lose. In response to changes in climate and socio-economic conditions, producers in this region will shift current cropping systems towards the annual cropping system to take advantage of positive aspects of projected climate changes or minimize adverse effects. Results also show that the value of climate impacts and adaptations is uncertain due to substantial uncertainties in climate model projections and the economic and policy environment in which producers operate.

Oral Presentation

Title: **Management outweighs climate change on affecting length of rice growing period for early rice and single rice in China during 1991-2012**

Authors: Xuhui Wang[1], P. Ciais[1], S. Piao[2], and L. Li[3]
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Abstract: Whether crop phenology changes are caused by change in managements or by climate change belongs to the category of problems known as detection-attribution. Three type of rice (early, late and single rice) in China show an average increase in Length of Growing Period (LGP) during 1991-2012: 1.0±4.8 day/decade (±standard deviation across sites) for early rice, 0.2±4.5 day/decade for late rice and 2.0±6.0 day/decade for single rice, based on observations from 141 long-term monitoring stations. Positive LGP trends are widespread, but only significant ($P<0.05$) at 25% of early rice, 22% of late rice and 38% of single rice sites. We developed a Bayes-based optimization algorithm, and optimized five parameters controlling phenological development in a process-based crop model (ORCHIDEE-crop) for discriminating effects of managements from those of climate change on rice LGP in China. The results from the optimized ORCHIDEE-crop model suggest that climate change has an effect on LGP trends that depends on rice types. Climate trends have shortened LGP of early rice (-2.0±5.0 day/decade), lengthened LGP of late rice (1.1±5.4 day/decade) and have little impacts on LGP of single rice (-0.4±5.4 day/decade). ORCHIDEE-crop simulations further show that change in transplanting date caused widespread LGP change only for early rice sites, which offsets 65% of climate change induced shortening of LGP. The primary drivers of LGP change are thus different among the three types of rice. Management, including shifting transplanting dates, changes in cultivars and agronomic practices, are predominant driver of LGP change for early and single rice. This study shows that complex regional variations of LGP can be reproduced with an optimized crop model. We further suggest that future rice crop modeling in global and regional scales should consider different types of rice and variable transplanting dates in order to better account the impacts of management and climate change.

Session 1.5 Stakeholders and Decision Support

Oral Presentation

Title: **EUROCLIMA Biophysical Modelling, for policy support on agriculture and climate change in Latin America and the Caribbean**

Authors: Maurits van den Berg and J. R. Baide

Abstract: EUROCLIMA is a program of regional cooperation between the EU and 18 countries in Latin America, focused on climate change. The specific objective of the current 2nd phase (since 2014) is to facilitate the integration of climate change mitigation and adaptation strategies and measures into Latin American public development policies and plans. Implementing partners are ECLAC, IICA, UNEP, EuropeAid and the JRC. National Focal Points, designated by Latin American governments, facilitate and guide the implementation of the programme and promote the application of the results. The JRC is responsible for the implementation of the biophysical modelling component of EUROCLIMA: to provide a common platform for sharing and developing data and model tools that can be used by Latin American institutions as a basis to test, assess and develop science-based questions relevant to climate change impact and risk response strategies relevant to agriculture. The core of this platform is the Biophysical Modelling Applications (BioMA) framework, which is currently used operationally for monthly crop forecasts across Europe. BioMA hosts several generic and crop-specific mainstream models with a common user interface and common input databases. Current efforts are focussed on enhancing the relevance of the framework to Latin American stakeholders through a participatory process, thus improving (i) the technical abilities of the framework, (ii) model parameterisation for the most important crops in the region and (iii) the relevance of impact and adaptation scenarios, while concurrently strengthening and broadening the network of experts as well as the dialogue with policy stakeholders in the region. The focus in this presentation is on the process followed, the challenges faced, and lessons learnt so far.

Oral Presentation

Title: **Impact of climate change on West Africa's agriculture: a mid-century assessment of the major economic outcomes for smallholder farmers**

Authors: Ibrahima Hathie[1], J. Clottey[2], A. Ly[1], D.S. MacCarthy[2], S. B. Freduah[2], A. Nenkam, M. Adams, G. K. Adiku[2], and P.C.S. Traore[3]

[1] Initiative Prospective Agricole et Rurale, Senegal , [2] University of Ghana, College of Agriculture and Consumer Science, Ghana, [3] International Crops Research Institute for Semi-Arid Tropics, Mali

Abstract: Agriculture in West Africa is mainly rainfed with a large number of smallholder farmers dependent on it for their livelihoods. The farming systems are dominated by cereals and legumes with livestock playing a significant role in the functioning of the systems. Current policies are aiming for the structural transformation of the agricultural sector but climate change remains a serious threat in the minds of many stakeholders. Assessing the sensitivity of these current agricultural production systems to climate change is of paramount importance given the likely consequences on the lives of the majority of the population. Based on 5 GCM predictions for RCP 8.5 and RCP 4.5, we simulate yields for the main crops in the farming systems of Navrongo (Ghana), Koutiala (Mali) and Nioro (Senegal) using DSSAT and APSIM crop models. Building on these twenty (20) different scenarios, we use the Multi-Dimensional tradeoff analysis framework (TOA-MD) to analyze the vulnerability of smallholder farmers to climate change in the three sub-regions of West Africa and explored how climate change will affect the distribution of income and poverty in these farming systems if adaptations do no occur. Differences in impact on vulnerability among the three sites will be discussed.

Session 1.5 Stakeholders and Decision Support

Oral Presentation

Title: **Nation-wide interdisciplinary assessments of climate change impacts on agriculture and food security**

Authors: Mariko Fujisawa, M. Cumani, H. Sasaki, and H. Kanamaru
FAO

Abstract: Food and Agriculture Organization of the United Nations has been supporting developing countries to conduct nation-wide assessments of climate change impacts on agriculture and food security. Such assessments strengthen evidence base about current and future climate impacts, and support effective adaptation planning and policies at the national level. Many existing climate change impact studies are conducted at plot (based on field experiments), or at global/continental scales. Our support to national assessments (with sub-national disaggregation) is also meant to fill the gaps in information at the national scale. The challenge of climate change and food security requires an interdisciplinary approach. Our methodology and software facilitate a collaborative integrated research that starts from statistical downscaling of climate projections, and then examines climate impacts on crop productivity, river water availability, forest species and biomass, agriculture market, household-level food security, and national economy. Capacity development and stakeholders' participation are another focus of our approach. National scientists are trained to use their country's own data to run impact models and produce information which responds to the stakeholders' needs. This would contribute to more sustainable institutional capacities of countries to periodically revise climate change information reflecting new scientific findings and evidence. We shall present the results of interdisciplinary assessments from the Philippines, Peru, and Morocco. The same approach will soon be implemented in Malawi, Zambia, Indonesia, and Paraguay as part of climate change adaptation and climate-smart agriculture projects and programmes.

Oral Presentation

Title: **Co-production of knowledge for Agricultural Adaptation: Using Climate Information and Crop Model outputs in the Wine Industry and the Maipo Adaptation Plan**

Authors: Francisco J Meza[1], D. Morales[1], S. Orellana[1], S. Vicuña[1], and P. Flores[2]
[1] Centro de Cambio Global. Pontificia Universidad Catolica de Chile, [2] Consorcio I+D Vinos de Chile

Abstract: With regards to risks for the sustainability of the agricultural industry, climate change has been escalating and it currently identified as one of the three major reasons for concern along with price volatility and labor availability.

Adaptation plans require the generation of information for scenario planning. Instead of top-down approaches that establish a one way interaction, we believe that stakeholders' involvement in the generation of future scenarios and the testing of models are fundamental to build trust on the tools that are used and to allow a more transparent communication among sectors that face common challenges.

Over the last three years, the Centro de Cambio Global, has been carrying a couple of projects that have been regarded as very successful. The first is the generation of climatic information and the use of simple models for wine suitability with the most important Chilean association of wine producers. The second corresponds to the establishment of a general adaptation plan for the Maipo basin with the direct participation of farmers, water utility, mining, hydropower companies, the local government and the civil society. Some of them have a long history of conflicts due to water use.

Here we present the most important features and lessons learnt form a partnership that has been established between the government, business and academic sectors.

Session 1.5 Stakeholders and Decision Support

11. *Poster Presentation*

Title: **Promoting regional collaboration for agricultural research and development in Latin America: experiences from a workshop on impact assessment and priority setting**

Authors: Guy Hareau[1], A. Petsakos[1], W. Pradel[1], A. Devaux[2], M. Ordinola[1]
[1] International Potato Center (CIP-HQ), Peru, [2] International Potato Center (CIP-Equador), Ecuador

Abstract: A large number of public and private initiatives exist nowadays in Latin America which aim to promote innovation in the agricultural sector as a response to existing and future challenges on production systems and nutritional security. To respond to this interest, the International Potato Center (CIP) and the Learning Alliance of Peru, in collaboration with the International Center of Tropical Agriculture (CIAT) and the International Food Policy Research Institute (IFPRI) organized a workshop to share methods, experiences and results from ex-ante and ex-post impact assessments of agricultural research relevant to the Latin America region. The workshop was oriented towards decision makers in agricultural research and development institutes, agricultural economists and social scientists working on these topics in different countries in Latin America. Its objective was to share recent results which generate evidence on the effectiveness of research-based rural development interventions and to increase participants' awareness on the different state-of-the-art methods for modeling the impacts of new technologies and climate change on social welfare, gender, and nutrition. The workshop managed to bring together different actors and contributed to the identification of institutional challenges which impede the collaboration and the development of stronger linkages between the various institutions. It also revealed research and development topics of common interest across different countries and institutions which rank high in policy makers' agendas and can provide a solid foundation for a network of impact assessment practitioners in the region.

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12. *Poster Presentation*

Title: **Stakeholders' Engagement in Indo-Gangetic Basin: Challenges and Opportunities**

Authors: Mohar S. Meena[1], N. Subash[2], H. Singh[2], S. K. Singh[1], W.L. Bartels[3], and A. Sullivan[4]
[1] ICAR-ATARI, [2] ICAR-IIFSR, [3] University of Florida, USA, [4] Bridgewater Consulting, South Africa

Abstract: The process of stakeholder engagement and creating dialogue aims to generate a concrete understanding that empowers, builds capacity and facilitates different modes of learning. The AgMIP aims to engage the stakeholders' in Indo-Gangetic Basin (IGB) to make full use of scientific outputs at national, regional and local decision makers in strategic climate-related adaptation planning. A pyramid approach was applied to interact and sensitise the stakeholders about AgMIP and research results at national, state, district and farm levels. There is no *'one size fits all'* model for stakeholder engagement. However, high influence and high power level stakeholders i.e., policy planners were focussed for influencing the decision making at higher level. Stakeholders' engagement gives an opportunity to contribute the stakeholders as an expert in their field for policy and program development. Effective stakeholder engagement enables better planned and more informed policies, projects, programs and services. The paper/poster also narrates challenges and opportunities in the stakeholders' engagement for consideration in AgMIP India plan.

Session 1.5 Stakeholders and Decision Support

13. *Poster Presentation*

Title: **Stakeholder Engagement: It stands and falls with the quality of engagement**

Authors: Hlamalani J. Ngwenya[1], O. Crespo[2], W. Durand[3], T. Mpuisang[4], W. Tesfuhuney[5], A. Fourie[6], and D. Cammarano[7]

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Abstract: Stakeholder engagement has become a buzz word for many companies as a part of corporate social responsibility. The concept is also gaining momentum in the research and other development space. However, stakeholder engagement stands and falls with the quality of engagement. The AgMIP project has introduced the stakeholder Unit to facilitate the engagement process as a interface between the researchers and relevant stakeholders. This poster will share the stakeholder engagement experience of the South African Agricultural Model Intercomparison and Improvement Project (SAAMIIP) with cases from South Africa and Botswana. The aim is to shown how stakeholder engagement is seen beyond a 'tick box' exercise; but rather a well thought through process that compels the research team to think together, plan together and make the best out of the process. It will also show the mapping of the stakeholders engaged throughout the different stages of the research process, how they find the information useful for different purpose and how their contributions is shaping the research process. Most importantly, how the articulation of the research key messages has evolved and changed overtime as influenced by stakeholder engagement.

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14. *Poster Presentation*

Title: **AgMIP-Pakistan Phase-II, A continued journey of AgMIPization; Expectations of stakeholders and outcomes.**

Authors: Fahd Rasul[1], A. Ahmad[1], M. Ashfaq[2], S. A. Wajid[1], T. Khaliq[1], S. Ahmad[3], K. Hussain[1], F. Riaz[4], and G. Hoogenboom[5]

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Abstract: The popularization of AgMIP got a new term for its outreach program and stakeholder liaison activities as "AgMIPization". The first phase results gave birth to new questions and triggered the idea of AGMIP protocols, the tools and the methodology awareness to general stakeholders who became well aware owing to the strenuous efforts put forth by AgMIP team. Several sessions on RAPs (representative agricultural pathways) were held in the length and breadth of Pakistan. Diversified experts shared their knowledge, opinions and perceived possible outcomes from climate, crops and livelihood scenarios to short, medium and long term impacts of climate change along with policy options and recommendations. The sensitization of stakeholders directly involved in crops and livestock was a major twist in activities. Key messages for the policy recommendations were discussed and presented in outreach activities to get a feedback for refining of the key messages. Meetings with subject specialists, meteorologists and high ups in the agricultural research, extension and education, bureaucrats and scientists from nationally reputed research organizations were held keeping in view the possible deliverables to farmers. Feedback results elucidated that farmers want simple solutions to their localized problems in short term and regard the long term broader impacts less valued, but still they remained hopeful that some good integrated work is going on and trying to learn model interventions for precise information. More number of people are sensitized on work of AgMIP with every rising sun and specially gender based involvement and sensitization was a commendable effort of AgMIP.

Session 1.6 Remote Sensing, Land-use, and Scaling

Oral Presentation

Title: **Soil Data Aggregation Effects in Regional Yield Simulations**

Authors: Holgen Hoffmann[1], G. Zhao[1], S. Asseng[1], M. Bindi[3], D. Cammarano[4], J. Constantin[5], E. Coucheney[6], R. Dechow[7], L. Doro[8], H. Eckersten[9], T. Gaiser[1], B. Grosz[7], E. Haas[10], B. Kassie[2], KC Kersebaum[11], R. Kiese[10], S. Klatt[10], M. Kuhnert[12], E. Lewan[6], M. Moriondo[13], C. Nendel[11], H. Raynal[5], P.P. Roggero[8], R. Rötter[14], S. Siebert[1], C. Sosa[6], X. Specka[11], F. Tao[14], E. Teixeira[15], G. Trombi[3], J. Yeluripati[16], E. Vanuytrecht17, D. Wallach[5], E. Wang[18], L. Weihermüller[19], Z. Zhao[18], and F. Ewert[1]

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Abstract: Large-scale yield simulations often use data of coarse spatial resolution as input for process-based models. However, using aggregated data as input for process-based models entails the risks of introducing errors due to aggregation (AE). Such AE depend on the aggregation method, on the type of aggregated data as well as on its spatial heterogeneity. However, previous studies indicated that AE in Central Europe might be largely driven by aggregating soil data. AE in yield could therefore be assessed prior to simulation for those regions with a distinct relationship between spatial yield variability and soil heterogeneity. The present study investigates the AE for soil data and its contribution to the total AE for soil and climate data for a range of different crop models. Soil data is aggregated by area majority in order to maintain physical consistency among soil variables. AE are assessed for climate and soil data in North Rhine-Westphalia, German, upscaling from 1 to 100 km resolution. We present a model comparison on AE for a range of environmental conditions differing in climate and soil for two crops grown under water-limited conditions. Winter wheat and silage maize yields of 1982-2011 were simulated with crop models after calibration to average regional sowing date, harvest date and crop yield. Results point to the importance of estimating AE for soil data. Ways to generalize from these results to other regions are discussed.

Session 1.6 Remote Sensing, Land-use, and Scaling

Oral Presentation

Title: **The AgMIP Coordinated Climate Crop Modeling Project (C3MP) – Differences In Climate Response Across 1100+ Crop Modeling Sets**

Authors: Alex C. Ruane[1], S. P. McDermid[2], and T. Mavromatis[3]
[1] NASA Goddard Institute for Space Studies, New York, USA, [2] New York University, New York, USA, [3] Aristotle University of Thessaloniki, Greece

Abstract: The ways in which crops respond to fundamental changes in carbon dioxide concentration ([CO_2]), temperature (ΔT), and precipitation (ΔP) hold the key to first order impacts of climate change on agricultural systems. This response may vary across locations, crop models, crop species, cultivars, and management systems. The AgMIP Coordinated Climate-Crop Modeling Project (C3MP) enlisted crop modelers around the world to run a set of standardized carbon dioxide ([CO_2]), temperature, and rainfall change experiments in their own crop model configurations. More than 100 crop modelers participated, examining over 15 species and 20 crop models, with simulation sets in more than 50 countries.

C3MP sites for maize, spring wheat, winter wheat, rice, soybeans, and peanuts provide the largest number of simulation sets and allow the most extensive evaluation. Ensemble mean responses reveal well-known features such as the lower response to elevated [CO_2] in C4 crops as compared to C3, but also show fundamental differences in temperature response due in part to the geographical locations where certain crops are most prevalent (e.g., wheat tends to be grown in cooler climates than maize). Uncertainty across simulation sets reveals heightened differences between simulation sets at extreme climate changes, particularly the high temperature conditions in which heat and water stress can be particularly damaging. C3MP results also demonstrate a strong interaction between mean climate change and climate variability, resulting in larger extremes under future climate conditions.

Oral Presentation

Title: **Integrated crop model uses remote sensing data to simulate crop growth and carbon flux data**

Authors: Jonghan Ko, S. Jeong, and J. Choi
Chonnam National University, South Korea

Abstract: A hybrid technique that incorporates crop modeling and remote sensing has the potential to strengthen the individual capabilities of both, i.e., the continuous crop growth reproduction using crop modeling and the detailed observation of crop conditions using remote sensing. In this study, we integrated a crop model able to use remote sensing data to simulate crop growth and carbon flux information. The current model was developed in order to extend the previously developed hybrid crop model (i.e., GRAMI-Rice) for possible applications in studying the influence of climate change on crops. To construct the model, a leaf-and-canopy carbon flux model was discretely formulated based on pre-existing modeling study outcomes. The carbon flux model was then unified with GRAMI-Rice, such that the assimilated model could simulate time-series information of hourly and daily carbon fluxes, as well as crop growth variables, and we found that the individual carbon model effectively reproduced the carbon fluxes of paddy rice (Oryza sativa). The integrated model will be further investigated for its capability to reproduce seasonal information regarding carbon fluxes and crop growth variables using operational satellite remote sensing data. We will also investigate the capability of the model to simulate the effects of climate change on crops. The current ongoing efforts show promise for simulating crop growth, determining remedial measures for securing future food crop production, and extending the applicability of current and future operational satellites for monitoring croplands.

Session 1.6 Remote Sensing, Land-use, and Scaling

Oral Presentation

Title: **Using Earth observation and ancillary data sources as alternative to household surveys for regional integrated assessments for maize production in the Free state of South Africa.**

Authors: Wiltrud Durand, D. Cammarano, O. Crespo, and A. Fourie

Abstract: Various regions of the world are undertaking regional assessments following AgMIP protocols and integrated assessment procedures. These protocols were created to link climate, crop and economic modelling through information technology components to assess the impact of Climate Change on future agricultural systems. It relies on household surveys to supply the necessary data inputs to the crop and economic models. In South Africa no such detailed survey data set could be obtained and an alternative method had to be developed. Taking into account that, although, most dynamic crop models have been developed and tested for plot scale (homogeneous fields), applications related to climate change, often require broader spatial scales that can incorporate considerable heterogeneity. This prompted the approach to use satellite imagery, producer independent crop estimate survey (PICES) and crop type classification to develop a maize crop field level land cover and linking this to regional enterprise budgets. Using Landsat and Spot images, 14 million hectare of field boundaries was digitized. The field crop boundaries were used as basis for an aerial-survey, identifying fields planted with crops. The identified crop type per field was used for satellite image classification. For the maize crop field level land cover all fields that were identified to have been panted to maize were integrated into one data basis. To establish crop management input for crop modelling, samples obtained from objective yield surveying were used to calculate the proportion of fields with certain row widths, planting dates and plant populations. The same proportion was used to assign the management strategies to all the fields within the Free State using GIS. Fertilization was based on the average modelled 50 year yield potential of each field. The soil properties required for crop yield modelling were derived using the identified soil series suitable for maize production from Terrain Units of land type maps within a GIS framework. This assigned each field a unique soil description. Pedo-transfer functions were used to calculate soil model inputs. Two sources of climate data, quinary catchments database and MERRA were linked to generate a continual coverage of climate data for the Free State Province for 29 (Global Circulation Models) GCMs and two Representative Concentration Pathways RCPs (4.5 and 8.5) for baseline (1980-2010) and mid-century (2040-270) climate change predictions based on AgMIP methodology. Using two crop models DSSAT and APSIM the impact of 5 selected climate change scenario's on production and economics were evaluated on dryland and irrigated maize systems using the Trade-off Analysis Multi-dimensional Model (TOA-MD) model with a minimum data set approach based and stakeholder outlooks in the form of representative agricultural pathways (RAPs).

Session 1.6 Remote Sensing, Land-use, and Scaling

15. *Poster Presentation*

Title: **Disentangling factors of landscape changes in Burkina Faso, the nexus between spatial modelling and remote sensing**

Authors: Camille Jahel*[1], Louise Leroux*[1], A. Bégué[1], M. Castets[1], C. Baron[1], and D. L. Seen[1]
[1] CIRAD, UMR TETIS, *C. Jahel and L. Leroux have equally contributed to the abstract and are thus joined ‘‘lead authors’’

Abstract: Rural areas of West Burkina Faso have seen notable transformations these last two decades due to high population growth and farming systems evolution. Satellite images acquired frequently and covering large areas are essential for detecting such landscape changes and long term trends. However, these images generally have coarse spatial resolutions and can only provide information about changes in the main vegetation patterns. The factors causing these changes are more difficult to determine, although there are essential for monitoring landscape evolution.

We hereby present a method based on multi-scalar modelling of past landscape dynamics crossed with changes in vegetation trends identified from coarse resolution satellite images. The aim of our presentation is to use the model to simulate and illustrate how land cover and land use changes may impact vegetation response by improving the qualification and understanding of the observed trends.

The cropping systems dynamics of the study area, the Tuy province of West Burkina Faso, were modelled with the Ocelet Modelling Platform over the last fifteen years through a multi-scalar model. The model was validated at local scale with information derived from high resolution images. At the same time, vegetation trends were analysed using Ordinary Least Square regressions based on MODIS NDVI time series. Simulated cropland change maps were then used to decompose the remote sensing-based trends. This allowed the spatial identification of factors responsible for the vegetation changes. The original approach we proposed here opens new opportunities for the understanding and monitoring of landscape changes using time series of coarse resolution satellite images.

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16. *Poster Presentation*

Title: **Determination of leaf area index and biomass value in the wheat fields with different method approaches using the remote sensing, LAI measuring device and manuel measuring**

Authors: Omer Vanli
Istanbul Technical University

Abstract: Population growth that restricts arable land in the world has increased the need for effective and efficient farming practices. Sustainable agriculture will be achieved in case of Fields that based on different user may be categorized and can be used. Knowing physiological properties of plant is an important issue to sustain agricultural activities and have high crop yields.

Monitoring of wheat growth period carefully, besides to provide a more accurate determination of pesticides and fertilizers application time, helps to make yield estimation. The light utilization rate of leaves that is the organ where generate the majority of photosynthesis and the yield is closely related to leaf area index (LAI). LAI which vary according to species and varieties of plants is also varies during the vegetation period.

In this study, wheat samples that taken unit per area and selected in the 4 different Fields in the Islahiye and Nurdagı regions is calculated manually LAI and also is weighed and recorded biomass values. Secondly LAI values that measured in the same areas and used LAI meter were recorded. Biomass and LAI calculated from NDVI that is found from remote sensing image in the same period were determined. Finally with the comparison all of this processes accuracy tests of the LAI and biomass values were made.

Key Words: Crop Yield, Leaf Area Index(LAI), NDVI, Biomass

Session 1.7 Wheat Model Intercomparison

Oral Presentation

Title: **Improved modelling of wheat processes through inter-comparison of multiple models**

Authors: Enli Wang[1]*, P. Martre[2,3]*, S. Asseng[4], F. Ewert[5], Z. Zhao[1], A. Maiorano[2,3], and the AgMIP-Wheat team

Abstract: While the multi-model ensemble modeling approach is useful to quantify prediction uncertainty in crop simulations, the approach itself does not necessarily lead to improvement in process understanding. We extend the model inter-comparison to investigate how the uncertainties in simulation results arise from process-level algorithms and parameterization in the models. We systematically compared 29 physiologically based wheat models in terms of how the key temperature-responsive physiological processes are simulated. We categorized the temperature response equations in the models into four types based on their shapes. To demonstrate the impact of the different temperature equations on simulated phenology, total above ground biomass and grain yield, we implemented the four types of temperature responses in the APSIM and SiriusQuality models and tested the modified models against the USDA 'Hot Serial Cereal' (HSC) field experiment. In addition, the uncertainty in simulation results from the two models caused by various temperature response functions was compared to those generated from the 29 models. Our analysis revealed contrasting temperature response functions for the same physiological process among different models. The range of simulated grain yield caused by variations of temperature response functions in APSIM and SiriusQuality was on average 52% and 64% of the uncertainty of the whole ensemble of 29 models, respectively. We further developed improved general temperature response functions for key developmental and growth processes of wheat. Implementation of these temperature functions in the APSIM and SiriusQuality model led to improved simulations of wheat yield against the HSC data across a wide temperature range.

Oral Presentation

Title: **Prediction of the rate of development and anthesis date using QTL-based parameters of an ecophysiological model for durum wheat**

Authors: Pierre Martre[1], R. Motzo[2], G. Sanna[2], A. M. Mastrangelo[3], P. De Vita[3], and F. Giunta[2]
[1] UMR LEPSE, INRA, Monptellier SupAgro, France; [2] Unit of Agronomy, Field Crops and Genetics, Department of Agriculture, University of Sassari, Italy; [3] CREA Cereal Research Centre, Italy

Abstract: Breeding for a fine tuning of crop development to target population of environments is an avenue for future increases in grain yield and adaptation to climate change. The use of ecophysiological modeling has been proposed to get insights into how genotype-by-environment interactions come about. However, models cannot account for the genetic basis of differences in response to the environment unless model parameters are linked with easily measurable physiological traits and known QTL or genes. Here, vernalized and non-vernalized plants of a population of recombinant inbreed lines (RILs) of durum wheat were grown under long and short days. Measured final leaf number and anthesis date data were used to calibrate five genotypic parameters of the SiriusQuality wheat model. A QTL analysis of the genotypic parameters was performed. Several QTL co-localized with previously identified QTL for earliness per se, cold requirement, and photoperiodic sensitivity. The performance of the model using either the original parameters or the QTL-based parameters was validated in three field experiments for the whole population of RILs and in more than nine year/sowing/location combinations for the two parents, which were not used in the QTL analysis. The QTL-based model predicted the final leaf number, the date of flag leaf ligule appearance, and the anthesis data for the validation data set with an error of 0.5 leaves, 4.2 days and 2.5 days, respectively. These information will allow simulating the impact of genetic recombination on crop development under new environmental conditions and will help breeders identifying genetic makers to fine tune the development of new cultivars to target environments.

Session 1.7 Wheat Model Intercomparison

Oral Presentation

Title: **Designing wheat ideotypes for a changing climate**

Authors: Mikhail A. Semenov and P. Stratonovitch
Computational and Systems Biology Department, Rothamsted Research, Harpenden, UK

Abstract: Global warming is predicted to increase adverse weather events that are considered a major threat for wheat production in Europe. To meet increasing demands for wheat, new wheat cultivars with improved yield potential and resilience to climate change will be required, putting severe pressure on breeders who must select for uncertain future. Crop modelling is a powerful tool to identify key traits for improvement and to quantify potential threats to wheat. Moreover, wheat ideotypes, optimised for a wide range of future climates and target environments, can be designed and tested in silico using a wheat simulation model. We used Sirius, a process-based model for wheat, to estimate yield potential of wheat ideotypes optimized for future climatic conditions in Europe as predicted by global climate models from the CMIP5 ensemble. Substantial increase in yield potential could be achieved through optimal phenology and extending grain filling and thereby improve resource capture and partitioning. However, the model predicted an increase in frequency of heat stress around flowering. Controlled environment experiments showed the detrimental effects of heat and drought at booting and flowering on grain numbers and potential grain size. The use of early maturing cultivars in areas of Europe with hotter and drier summers helps to escape from excessive heat and drought stress during the reproductive period, but results in lower yields. The refined Sirius wheat model, that incorporates responses to heat and drought stress around flowering, showed that yield potential and yield stability would be substantially affected for wheat ideotypes sensitive to these stresses. Therefore, to increase yield potential and resilience to climate change, increased tolerance to heat and drought stress during reproductive development should remain a priority for the genetic improvement of wheat.

Oral Presentation

Title: **Model improvements reduce the uncertainty of wheat crop model ensembles under heat stress**

Authors: Andrea Maiorano[1], P. Martre[1], S. Asseng[2], F. Ewert[3], D. Wallach[4], and the AgMIP Wheat Team
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Abstract: Model improvements can reduce uncertainty of climate impact assessments and as a consequence reduce the number of models required for an acceptable level of simulation uncertainty. Here 15 wheat crop models were improved for the simulation of heat stress impacts and the effect on multi-model ensemble (MME) performances and predictive skills were investigated. The models were improved through re-parameterization or by the incorporation or modification of heat stress effects on phenological development and/or growth processes. Field data from the USDA 'Hot Serial Cereal' (HSC) experiment and the 'International Heat Stress Genotype Experiment' (IHSGE) coordinated by CIMMYT were used to calibrate and evaluate the improved models, respectively. The results show that model improvements decreased the variation of simulated grain yields on average by 26% in the independent evaluation dataset for crops grown in mean seasonal temperatures > 24°C. The mean squared error for grain yield of the model population decreased by 37%. The prediction skills of the model population increased by 47% due to a 26% reduction in the model population uncertainty range. The latter improvement was mostly due to a decrease in MME variance. The number of models required for MME impact assessments was halved, from 15 with the unimproved original models to 8 with the improved models. We conclude that model improvements using field-based experimental datasets can increase the simulation and predictive skills of MME and reduce the number of models required for practical impact assessments.

Session 1.8 Livestock and Grasslands

Oral Presentation

Title: **Large scale impacts of grazing management under climate change**

Authors: Susanne Rolinski[1], I. Weindl[1,2], J. Heinke[1,3], B.L. Bodirsky[1,3], A. Biewald[1], C. Müller[1], and H. Lotze-Campen[1,4]
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Abstract: The potential of grasslands to sequester carbon and provide feed for livestock production depends on climatic conditions but also on management and grazing pressure. We use a global dynamic vegetation and agriculture model (LPJmL) to study spatially explicit feedbacks between grazing/mowing and primary productivity and impacts on soil carbon content under different management settings. Applying different animal densities as well as grazing durations, we quantify impacts on the carbon cycle due to climatic conditions and the grazing pressure and timing. Varying the density of grazing animals also enables to find local optimal densities which simultaneously enhance primary productivity and grass yield while maintaining soil carbon. We show that low animal densities increase grass productivity whereas high grazing pressure deteriorates the plants' ability to recover. The global application of this concept provides information on potential grass yields under varying climatic conditions to explore options for sustainable pasture-based livestock production.

Oral Presentation

Title: **Impact of climate change on the livestock component of mixed farming systems: modelling evidence from regional integrated assessments across sub-Saharan Africa and South Asia**

Authors: Katrien Descheemaeker[1], M. Zijlstra[1], T. Ramilan[2], T. Senda[3], E.C. Timpong-Jones[4], A. Nenkam[5], M. Sajid[6], S. Singh7, G. Baigorria[8], M. Adam[9], K. Shalander[10], and A. Whitbread[10]
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Abstract: Mixed crop–livestock systems play an important role in global food production and livelihood provision of millions of rural households. Climate change is projected to alter the functioning and productivity of these systems. Although for many regions the impact of climate change is projected to be large, many uncertainties persist, in particular with respect to impacts on livestock and grazing components, whole-farm dynamics and heterogeneous farm populations. Using an integrated modelling framework we simulated fodder and grassland productivity for current and future climate scenarios. This data was subsequently used as input in a dynamic livestock model LIVSIM to investigate climate change impacts on animal productivity. The modelling framework simulates entire farm populations, thus capturing the effects of farm heterogeneity. Livestock-related output variables included milk production, herd dynamics, calving and offtake rates, and mortality rates. In integrated assessments, these livestock outputs are used in economic models at the household level. The modelling approach was applied across four distinct regions, including southern Africa, West Africa, Pakistan and India. This allowed capturing a wide diversity in farming systems and climate scenarios. Also various adaptation options targeting the crop, animal or grazing land components of mixed crop-livestock systems were investigated. Strong impacts of climate change and adaptation packages on livestock productivity were found in particular where impacts on feed quantity and quality were large. The differences in outputs were attributed to differences in growth-defining and growth-limiting factors across the four regions.

Session 1.8 Livestock and Grasslands

Oral Presentation

Title: **Modelling nitrogen dynamics including leaching in intensive crop rotations on productive organic-sandy soils after the break-up of grassland**

Authors: Munir P. Hoffmann[1], R. P. Rötter[1], J. Isselstein[2], M. Kayser[2]
[1] Crop Production Systems in the Tropics, University of Göttingen, Germany, [2] Grassland Science, University of Göttingen, Germany

Abstract: Developing site-specific nutrient management strategies is one option, where crop growth models have demonstrated they can play a special role. Against this background we evaluated APSIM in a two-year field trial comparing two rotations (maize monoculture and barley-mustard-maize) and two mineral fertilizer regimes (zero and high, i.e 160 and 120 kg N ha-1 for maize, respectively for barley) on three productive organic-sandy soils in North-west Germany after the break-up of grassland. After calibration APSIM simulated the independent data well: biomass (RMSE 17%, Index of agreement (IA) 0.97), N uptake (20%, 0.91), Nmin 0-30cm (53%, 0.91), Nmin 0-90cm (69%, 0.89), soil water 0-30 cm (30%, 0.84), soil water 0-90 cm (17%, 0.87) and N-leaching (39%, 0.93). Subsequently, we applied the model to a long-term simulation experiment using the same design as in the evaluation trial.

For maize monoculture, no differences were simulated for biomass or N-uptake between zero and high fertilizer due to high mineralization so that even the high N-demand of 200 kg ha-1 was satisfied. However, N-leaching for the fertilized treatment was very high (two years total 369 N kg ha-1). In the barley-mustard-maize treatment barley biomass was 20% lower for the zero fertilizer. Leaching losses (249 kg ha-1) were lower in comparison to the monoculture due to the cover crop after barley; however, in the second year large losses were simulated after maize. Future research should address modelling of gaseous losses, a neglected topic that is crucial for advancing understanding of the N-dynamics in the system.

Oral Presentation

Title: **Assessing simulation models for field scale projections of pasture GHG emissions and yields**

Authors: Fiona Ehrhardt[1], J. F. Soussana[1], V. Snow[2], R. Sandor[3], R. McAuliffe[2], G. Bellocchi[3], and the consortium *
[1] INRA, Paris, France, [2] AgResearch, Lincoln Research Centre, New Zealand, [3] INRA, Grassland Ecosystem Research, France, * L. Brilli, C. Doris, N. Fitton, M. Harrison, S. Jones, M. Kirschbaum, K. Klumpp, Mark Liebig, M. Lieffering, R. Martin, L. Merbold, A. Moore, V. Myrgiotis, P. Newton, S. Rolinski, L. Wu

Abstract: Over the last 30 years, simulation models have been extensively developed for agricultural greenhouse gas emissions (GHG) and soil carbon stock changes. Nevertheless, the predictive ability of these models has not been assessed and inter-compared and the use of ensemble, rather than single, models for projections has not been evaluated at international scale. The Soil C-N Group of the Global Research Alliance (GRA) on agricultural GHG has initiated an international model benchmarking and inter-comparison in this area for both crop and pasture models. An initial stock take has been conducted, resulting in the selection of datasets from five temperate grasslands and five arable crop rotation sites spanning four continents. A total of 24 models used in 11 countries for the prediction of GHG emissions in crop and grassland systems are contributing. These models have been benchmarked and inter-compared at these sites in a fully blind procedure. The study has been set up with five successive steps that gradually release information to the modeling groups, ranging from fully-blind application of the models to complete availability of the experimental measurements. Model simulations are compared to experimental measurements for crop yield and grassland dry-matter production, N2O emissions, soil C stocks and net CO2 exchanges. Results with temperate grasslands are presented, showing that multi-model estimates are more robust for projections of GHG emissions and removals than those from single models. Moreover, the sensitivity to climatic drivers of calibrated models has been analyzed within the grassland group of the AgMIP international program and projections of climatic impacts on GHG emissions are shown based on this ensemble. Based on these results, the use of simulation models for field scale projections of current and future GHG emissions and removals from pastures is discussed.

Session 1.8 Livestock and Grasslands

17. *Poster Presentation*

Title: **Modeling Climate Change Impacts On Livestock Productivity In Semi-Arid Zimbabwe**

Authors: Trinity Senda[1], K. Deschemaeker[2], S. H. K. Tui[3], P. Masikati[4], G. Sisito[1], O. Crespo[5], and B. Francis[6]
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Abstract: In semi-arid Zimbabwe livestock play a vital role in the livelihoods of small-scale farmers. Current productivity is low due to various inefficiencies, but there is a huge potential for farmers to obtain significant incomes from strategic sales and improved management. Climate variability and change are a threat, especially through negative impacts on the major fodder sources, such as rangelands and crop residues. This study used the LivSim model to simulate the impacts of climate variability and change on livestock productivity by taking into account the effects on the feed base. Model calibration was done based on local breed data from farms and experiments. The feed inputs consisted of grass from rangelands and crop residues from maize, sorghum and groundnut, obtained from crop modelling using Apsim and DSSAT. Different climate scenarios were created using two contrasting GCMs. Milk yield, offtake and mortality rates were simulated for a 30-year period for 160 households. The study also assessed the benefits of adaptation by including a forage legume (Mucuna pruriens) in rotation with maize, in addition to micro-dosing fertilizer on maize. The results indicated that in the hot and dry climate scenario, crop residue and rangeland production declined, leading to reduced livestock productivity. The adaptation package can mitigate the negative impacts of climate change on milk production, offtake and mortality. Farmers can thus reduce their vulnerability to climate change by increasing feed quantity and quality. Improved market access becomes essential for farmers to benefit from improved offtake and continued investment in adaptation packages.

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18. *Poster Presentation*

Title: **Parameterizing LivSim for simulating growth of the Ghana shorthorn cattle**

Authors: Eric Timpong-Jones[1], B.S. Freduah[1], S.G.K. Adiku[1], A. Nenkam[2], M. Adam[3],T. Ramilan[4], and D.S. MacCarthy[1]
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Abstract: An important component of the farming system in Ghana is livestock production. Livestock, especially cattle production is heavily dependent on rainfall for the production of forages to feed them. Projected increase in temperature and shifts in rainfall patterns due to climate change is expected to affect the level of livestock production and livelihood of the resource poor animal herders in Ghana. To gain insight into the livestock-climate nexus, we conducted a study in Tamale in the Northern region of Ghana to parameterize the LivSim (Livestock Simulator) model for the simulation of growth of the Ghana Shorthorn cattle. The main objective was to quantify milk and calf production by the various smallholder farmers in the community. A survey of 261 households out of which 96 owned livestock was conducted to obtain observed data on milk yield, calving frequencies, among others. Other data required by LivSIM such as the minimum and maximum bodyweights of both male and female Ghana Shorthorn were obtained from the literature. The number of cattle owned by the households interviewed ranged from 2-47 with majority having a herd size less than twelve. The herd composition was estimated to be 72% female and 28% male. Preliminary simulation results showed that the herd dynamics could be well captured for an initial period of 5 years, after which there was divergence between the simulated and the observed. Further current efforts are directed to the improvement in parameter values especially those relating to the potential growth rates and the compensatory growth rate.

Session 2.1 Scenarios and RAPs

Oral Presentation

Title: **Developing National Representative Agricultural Pathways (RAPs) – Reflections, lessons and outcomes from high level stakeholder consultations in India**

Authors: Nataraja Subash[1], H. Singh[1], A.S. Panwar[1], S.V. Singh[2], M.S. Meena[3], B. Singh[4], G. P. Paudel[4], V. Geethalekshmi[5], P. Paramasivam[5], A. Lakshmanan[5], S. Nedumaran[6], D. M. Kadiyala[6], S. S. Reddy[6], R. O. Valdivia[7], J. M. Antle[7], A. Sullivan, W.L. Bartels[8], C. Mutter[9], S. P. McDermid[10], C. Rosenzweig[11], James. W. Jones[8]
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Abstract: Agricultural Pathways and Scenarios are very well recognized by the Global Scientific Community for impact assessment at different spatial scales. Representative Agricultural Pathways (RAPs) are designed to extend global and regional assessment of agricultural systems. RAPs are based on the integrated assessment framework developed by the AgMIP (Agricultural Model Intercomparison and Improvement Project) protocols. RAPs involve bio-physical, socio-economic and policy drivers which explain the plausible sectoral development pathways which are useful for integrated assessments of climate change through linking climate-crop-economic models at different spatial scales. Under AgMIP Phase 2 protocols, we have selected different locations in Northern and Southern India, representing different farming systems and developed local/regional RAPs through engagement of stakeholders and identified relevant drivers for region-specific farming systems. These RAPs must be logically consistent with the national and global RAPs. In India, agriculture is a state subject, and most of the policies developed at the national level influence local and regional agricultural development because of the federal nature of the Government. Hence, there is a need to develop RAPs at the national level, which is consistent with local and global RAPS. This poster, shares experiences and outcomes of National RAPs for India developed through a rigorous process involving stakeholder consultations, storylines and narratives based on past trends and empirical literature. It emerged that national RAPS is an important link between local and global RAPS and provides sound basis for integrated assessment of climate change impact on predominant farming systems of India.

Session 2.1 Scenarios and RAPs

Oral Presentation

Title: **Development of a Climate –Sensitive Representative Agricultural Pathways (RAPs) for West Africa: Stakeholder Interactions**

Authors: Ibrahima Hathie[1], J. Anaglo[2], S.G.K. Adiku[2], D.S. MacCarthy[2], and P.C.S. Traore[3]
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Abstract: Climate change is a major determinant of agricultural productivity, especially for many developing countries. The magnitude of the climate change would depend on the Representative Agricultural Pathways (RAPs) pursued by these countries. In this study, two RAPs were considered: (i) RAP5, which signifies rapid growth supported by high energy investments and (ii) RAP4 which emphasizes long-term sustainability with moderate inputs. This study aimed at developing these RAPs with different stakeholder groups regarding the plausible changes in the elements of agricultural production and its environment that are likely to be impacted by climate change in the near-term in Ghana, Mali and Senegal under the two RAPs. Three stakeholder groups were selected for this study; Agricultural Researchers from academic institutions, End-user stakeholders, Upper East Region of Ghana, the Koutiala area in Mali and the Nioro district in Senegal, and Policy-maker stakeholders from various climate-change related NGOs and Government Ministries of the three countries. The success of RAP4 in minimizing climate change impact would hinge on issues such as pricing policies, education and extension service availability and willingness of consumers to pay premium prices. The current production and demand conditions in these countries appear to follow RAP5 which is mainly state led, and requires considerable input such as fertilizers, supplementary irrigation to offset climate change effects, increased machinery use that would increase production acreages, among others, to support rapid agricultural growth that would meet the increasing demand. In this case, opportunities for environmental sustenance is limited. There were few disagreements between the groups relating to the direction and magnitude of change of a set of variables for each RAP. We conclude that a blend of RAPs 4 and 5 might be more appropriate with the hope that there must be growth while sustainability cannot be ignored.

Oral Presentation

Title: **Developing Representative Agricultural Pathways: Experiences and Learning across four sites in india**

Authors: Harbir Singh, N. Subash, G. Paudel, B. Singh, M. S. Meena, S. Singh, R. Valdivia and G. Baigorria

Abstract: The concept of representative agricultural pathways (RAPS) is being used by global research community to integrate sector-specific and region-specific aspects of economic development that are not addressed at the global level. Development of RAPS which are consistent with higher level pathways (e.g., SSPs) helps in construction of model-specific and location-specific scenarios which can be used for climate change impacts, adaptation and vulnerability assessment. The process of RAPS development using AgMIP protocols was initiated in Phase I with the development of business as usual (BAU) RAPS for two locations (Meerut and Karnal) of the Indo-Gangetic Basin (IGB) of India. This process was further used in Phase II to capture location-specific socio-economic, biophysical and policy variables for two distinct sites (Faizabad and Samstipur). This presentation discusses the process of RAPS development at four study sites in the IGB and shows how the qualitative RAPS narratives can be parameterized for making location-specific analysis of climate change impacts through economic modeling (TOA-MD). The future production systems may be more sustainable or unsustainable depending on a host of development drivers (socio-economic and policy). RAPS development framework enables to analyze these different development scenarios through modeling. Differences in understanding the relevance of the problem and reconciling divergent views of the stakeholders would be discussed to derive lessons for developing local level RAPS.

Session 2.1 Scenarios and RAPs

Oral Presentation

Title: **Representative Agricultural Pathways for Europe**

Authors: Anne Biewald[1], H. Lotze-Campen[1], Franz Sinabell[2], Andrea Zimmermann[3]
[1] Potsdam Institute for Climate Impact Research, Germany, [2] Österreichisches Institut für Wirtschaftsforschung, Austria, [3] University of Bonn, Germany

Abstract: Agricultural aspects have been covered in the scenario process on shared socio-economic pathways (SSPs), but only to a limited extent. In order to analyze the future dynamics of agricultural development they need to be complemented and specified by Representative Agricultural Pathways (RAPs), which cover different aspects of agricultural development as for example European agricultural and domestic policy, environmental policies, different livestock management systems, cropping systems or irrigation efficiencies.

In this paper we will develop a general framework for RAPs where we define for each SSP the corresponding specific agricultural development. Some aspects of the above mentioned specifics can be derived from the definitions in the SSPs, as for example irrigation efficiencies which are linked to technological development. Agricultural policies on the other hand are not included in the SSP definitions. Here we will define agricultural and environmental policies, including the available funding in each area of the common agricultural policy (CAP) (pillars 1 and 2).

As RAPs can only to a small degree be developed as European guidelines and implemented unilaterally, it is important to translate the overall storylines into specific scenario parameterization at national levels. Concerned by this are 1. national policies, as well as the agri-environmental schemes of the CAP in Pillar II, 2. livestock efficiencies and the development of extensive and intensive farm management, and 3. crop management systems.

Additionally we will define which respresentative concentration pathways (RCPs) will match best the future agricultural and agro-economic trajectories.

Session 2.1 Scenarios and RAPs

Oral Presentation

Title: **New methods for exploring future farms with stakeholders: the experience of AGMIP's crop livestock intensification project in semi-arid Zimbabwe**

Authors: Sabine Homann-Kee Tui[1], P. Masikati[2], K. Descheemaeker[3], G. Sisito[4], B. Francis[5], M. Wengawenga[6], A. Gungulo[7], T. Senda[4], and O. Crespo[8]
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Abstract: New scenario concepts are needed to implement impact and vulnerability assessment that is logically consistent across global, regional and local scales, and provide data and information about climate change, vulnerability, adaptation, mitigation and impacts at the local scale. The Crop Livestock Intensification Project (CLIP) tests pathways and scenarios, for smallholder farming systems in semi-arid Zimbabwe, Nkayi district. We involve both researchers and stakeholders in an iterative process of systems re-design, at different scales: At the community scale we engage farmers to inform adaptation options that are grounded in context and identify. At intermediate provincial scale, series of Representative Agricultural Pathways (RAPs) were developed with incremental and drastic assumptions, illustrating bio-physical and socio-economic drivers, associated capabilities, challenges and opportunities. Translating RAPs and adaptation packages in order to visualize climate vulnerability and impacts brought several benefits: First, researchers of different disciplines collaborate on the analyses of entire agricultural systems, including farm and off-farm activities and not limited to individual crops or technical aspects. Second, this approach simulates future worlds in which climate change would be occurring, along with institutional and policy implications for more effective adaptation. Third, context specific adaptation packages can be designed useful to inform investments in agricultural research and development. Finally, the approach takes into account the heterogeneity of farm communities, thus tailoring adaptation options to the needs and interests of specific farm types. These benefits are not theoretical: We can identify tangible opportunties and future ways in a particular context that are attainable under given conditions as those found in rural Zimbabwe.

Oral Presentation

Title: **Process for the development of representative agricultural pathways for cotton wheat cropping system in Punjab, Pakistan**

Authors: Muhammad Ashfaq[1], I.A. Baiq[2], J. Nasir[1], and I. A. Chattha[1]
[1] Uni. of Agriculture-Faisalabad, Pakistan, [2] PMAS-Arid Agriculture University Rawalpindi, Pakistan

Abstract: Agricultural production systems are under an evolutionary process in terms of biophysical, institutional/policy, technological advancement and socioeconomic conditions. Farm mechanization leads to disturbances in natural ecosystem. For the apprehension of these changes RAPs have been developed to determine the future agricultural production systems. Key indicators were selected, reviewed comprehensively and shared with the experts and team members. RAPs narratives were drafted by economists and shared with other team members for their input. Consultative sessions were planned and material was prepared and shared with the experts. In first RAPs meeting experts from relevant disciplines were invited. The selected experts included, economist, soil scientist, plant pathologists, entomologist, irrigation and water management experts, plant and animal breeders, livestock experts, sociologist and progressive farmers. Three RAPs consultative sessions were held. In the first RAPs meeting it was concluded that it was difficult to get the feedback on RAP4 and RAP5 at the same time in the same meeting. Second RAPs meeting was held to get the insight from experts and increase the agreement on opinion. It helped for the refinement of RAP4. The third meeting arranged for RAP5. Complete documentations of RAPs sessions had been completed and incorporated in DevRAP matrix. After refinement crop modelers also consulted and their suggestions regarding variable selection were incorporated in the DevRAP matrix. The main challenges were to segregate RAP4 and RAP5, agreement, especially on policy variables. The expert's opinions were quite logical and the main findings and challenges confronted will be presented in the AgMIP6 Global workshops.

Session 2.1 Scenarios and RAPs

19. *Poster Presentation*

Title: **Representative Agricultural Pathways (RAPs) and Scenario design with stakeholders for exploring climate change impacts, vulnerability and adaptation options of farming systems in Zimbabwe**

Authors: Buhle Francis[1], S. H.K. Tui[2], G. Sisito[3], T. Senda[3], K. Descheemaeker[4], P. Masikati[5], O. Crespo[6], and H. Mlilo[2], D. Nyoni[7], and E. Moyo[8]
[1] Institute of Development Studies, National University of Science and Technology (IDS-NUST), Zimbabwe, [2] International Crops Research Institute for the Semi-arid Tropics (ICRISAT), Zimbabwe, [3] Matopos Research Institute, Zimbabwe, [4] Plant production systems, Wageningen University, The Netherlands, [5] World Agroforestry Cent

Abstract: Smallholder farming systems like in semi-arid Zimbabwe face short and long-term challenges induced by variable and changing climate. Short-term benefits must be complemented with long-term sustainability goals. Current productivity levels are extremely low, institutional support systems weak and value chains not fully functional. As a result most of the rural population has little opportunities to evolve out of poverty. While conventional agricultural research and development focus on the farm-scale, we argue that higher level decision makers need to be more involved in order to develop and support appropriate change. The Crop Livestock Intensification Project engaged stakeholders in an iterative process of scenario design, Representative Agricultural Pathways (RAPs), and translated the biophysical and socio-economic trends into integrated climate-crop-livestock-economic modeling. The co-creation and revision of future scenarios involved researchers and stakeholders across a range of disciplines. The tested scenarios illustrate that currently promoted technologies towards better-integrated crop livestock systems can offset the impacts of climate change (incremental change). Yet, more transformative interventions enabled by policy and institutional interventions would be required in order to lead people out of poverty. The engagement process helped stakeholders understanding systems dynamics towards coherent and plausible futures, impacts of climate change and other socio-economic drivers, and ways for agricultural systems to adapt within a particular context. It allowed actors to think beyond immediate constraints and consider cross-disciplinary influences. Stakeholders became active partners in the research process and outcomes, a new way to influencing policy and institutional decisions.

Session 2.1 Scenarios and RAPs

20. *Poster Presentation*

Title: **Developing National Representative Agricultural Pathways (RAPs) – Reflections, lessons and outcomes from high level stakeholder consultations in India**

Authors: Nataraja Subash[1], H. Singh[1], A.S. Panwar[1], S.V. Singh[2], M.S. Meena[3], B. Singh[4], G. P. Paudel[4], V. Geethalekshmi[5], P. Paramasivam[5], A. Lakshmanan[5], S. Nedumaran[6], D. M. Kadiyala[6], S. S. Reddy[6], R. O. Valdivia[7], J. M. Antle[7], A. Sullivan, W.L. Bartels[8], C. Mutter[9], S. P. McDermid[10], C. Rosenzweig[11], James. W. Jones[8]
[1] ICAR-IIFSR, [2] ICAR-NDRI, [3] ICAR-ATARI, [4] CIMMYT, [5] TNAU, India, [6] ICRISAT, [7] Oregon State University, USA, [8] University of Florida, USA, [9] Columbia University, USA, [10] New York University, USA, [11] NASA GISS, USA

Abstract: Agricultural Pathways and Scenarios are very well recognized by the Global Scientific Community for impact assessment at different spatial scales. Representative Agricultural Pathways (RAPs) are designed to extend global and regional assessment of agricultural systems. RAPs are based on the integrated assessment framework developed by the AgMIP (Agricultural Model Intercomparison and Improvement Project) protocols. RAPs involve bio-physical, socio-economic and policy drivers which explain the plausible sectoral development pathways which are useful for integrated assessments of climate change through linking climate-crop-economic models at different spatial scales. Under AgMIP Phase 2 protocols, we have selected different locations in Northern and Southern India, representing different farming systems and developed local/regional RAPs through engagement of stakeholders and identified relevant drivers for region-specific farming systems. These RAPs must be logically consistent with the national and global RAPs. In India, agriculture is a state subject, and most of the policies developed at the national level influence local and regional agricultural development because of the federal nature of the Government. Hence, there is a need to develop RAPs at the national level, which is consistent with local and global RAPS. This poster, shares experiences and outcomes of National RAPs for India developed through a rigorous process involving stakeholder consultations, storylines and narratives based on past trends and empirical literature. It emerged that national RAPS is an important link between local and global RAPS and provides sound basis for integrated assessment of climate change impact on predominant farming systems of India.

Session 2.2 Nutrition and Food Security

Oral Presentation

Title: **Developing a value chain analysis framework to examine the health and environmental trade-offs of dietary patterns: A case study of the Mediterranean diet**

Authors: Shauna Downs[1] and J. Fanzo[2]
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Abstract: Although overall healthy diets tend to be promoted as being sustainable for planetary health, there is evidence to suggest that there may be trade-offs between health and the environmental impacts of producing these diets. Without having a way to measure those trade-offs it makes it difficult for consumers to make decisions about which foods are both healthy and sustainable. The overall aim of this study was to: 1) compile a dashboard of metrics to examine the health and environmental trade-offs of dietary patterns at each step of the value chain and 2) apply it to the Mediterranean diet. A review of the literature was conducted to identify key indicators for examining the environmental, economic, health, social and ecological impacts of food production and the way it moves along the value chain. Existing data sources were then compiled in order to apply the dashboard of metrics to the Mediterranean Diet. Although many components of the Mediterranean diet (vegetables, fruit, legumes, whole grain cereals) are both healthy and sustainable, there are aspects of the diet that have a larger environmental footprint (dairy, fish and olive oil), which will only be exacerbated with climate change. Downstream climate impacts of extreme weather conditions will further complicate access to sustainable diets due to food price volatility. The framework developed as part of this study could be applied to other dietary patterns or specific food groups with the view to informing the development of solutions aimed at reorienting production and consumption patterns around sustainable diets.

Oral Presentation

Title: **Global and regional health impacts of future food production under climate change: a modelling study**

Authors: Marco Springmann[1], D. Mason-D'Croz[2], S. Robinson[2], T. Garnett[1], H. C. J. Godfray[1], D. Gollin[1], M. Rayner[1], P. Ballon[1], and P. Scarborough[1]
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Abstract: One of the most important consequences of climate change could be its impact on agriculture. While much research has focused on questions of food security, less attention has been devoted to assessing the wider health impacts of future changes in agricultural production. We estimate excess mortality due to agriculturally mediated changes in dietary and weight-related risk factors by cause of death for 155 world regions in the year 2050.

We linked a detailed agricultural modelling framework, the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT), to a comparative risk assessment of changes in fruit and vegetable consumption, red-meat consumption, and body weight for deaths from coronary heart disease, stroke, cancer, and an aggregate of other causes. We calculated the change in the number of deaths due to climate-related changes in weight and diets for the combination of four emissions and three socio-economic pathways, which each included six scenarios with variable climatic inputs.

The model projects that by 2050 climate change will lead to per-capita reductions of 3.2% (± 0.4%), 4.0% (± 0.7%), and 0.7% (± 0.1) in global food availability, fruit and vegetable consumption, and red-meat consumption, respectively. Those changes were associated with 529,000 climate-related deaths globally (95% confidence interval (CI): 314,000-736,000), representing a 28% (95% CI: 26-33%) reduction in the number of deaths that would be avoided due to changes in dietary and weight-related risk factors between 2010 and 2050. Twice as many climate-related deaths were associated with reductions in fruit and vegetable consumption than with climate-related increases in the prevalence of underweight, and most climate-related deaths were projected to occur in South and East Asia. Adopting climate-stabilization pathways reduced the number of climate-related deaths by 29-71% depending on their stringency.

Session 2.2 Nutrition and Food Security

Oral Presentation

Title: **Food system metrics for quantifying nutrition and sustainability outcomes**

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Abstract: Human nutrition needs have not been fully addressed in most food security assessments conducted to date, which have generally focused only on achieving adequate calories, rather than including dietary diversity and micronutrient adequacy, both of which are critical to maintaining a healthy overall nutritional status. In addition, sustainability considerations have been absent, despite the tremendous economic, environmental, and social implications of meeting accelerating food demand in the face of water shortages and climate change. In response to these limitations, a new methodology has been developed based on the concept of "sustainable nutrition security" (SNS). This novel assessment methodology fills these gaps by defining seven metrics, each based on a combination of multiple indicators, for use in characterizing sustainable nutrition outcomes of food systems: (1) food nutrient adequacy; (2) ecosystem stability; (3) food affordability and availability; (4) sociocultural wellbeing; (5) food safety; (6) resilience; and (7) waste and loss reduction. Each of the metrics comprises multiple indicators that are combined to derive an overall score (0–100). The metrics have already been used to compare current food system performance in nine countries at varying stages of economic development. Future research challenges include looking at individual diets and incorporation of the metrics into models. A novel SNS assessment methodology based on these metrics can be deployed by decision-makers and investors to set meaningful goals, track progress, and evaluate the potential impact of food system interventions intended to improve sustainability and human nutrition outcomes.

Oral Presentation

Title: **Interactions between environmental change, agriculture, nutrition and health: an evidence-based framework**

Authors: Hanna L Tuomisto[1]. P.F.D. Scheelbeek[1], Z. Chalabi[2], M. Ezzati[3], R. Green[1], A. Haines[1,2], S. S. Myers[4], R. Smith[2], and A. D. Dangour[1]
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Abstract: Background: Environmental changes, such as climate change, increased ground level ozone, and changes in water availability, pests, pathogens and pollinators, have been shown to likely cause significant impact both on agricultural yields and crop quality over the next 20-30 years. However, up till now, no comprehensive overview of all interactions between each of these factors has been developed, nor have the critical pathways been identified that link environmental change – via agricultural production and crop quality – to diets and health outcomes in the future. Furthermore, there are no existing overarching models testing whether these environmental changes are likely to result in quantifiable impacts on nutrition and health.

Methods & Results: An interdisciplinary approach was used to develop a framework for linking the multiple interactions between environmental change, agricultural productivity and crop quality, population-level food availability, dietary intake and health outcomes. The strength of evidence for each pathway was assessed through literature reviews, and knowledge gaps were highlighted. Furthermore, the "critical pathways" that are likely to have the highest impact on future diets and health outcomes were identified.

Conclusions & Implications: The evidence based framework gives a clear overview of the multidimensional and complex interactions between environmental change, diets and health, and it forms the analytical baseline for future modelling and scenario testing. The future research will build inter-sectorial models and datasets for assessing the impacts of environmental change on agricultural production, food availability, nutrition and health.

The project is supported by the Wellcome Trust Our Planet, Our Health programme

Session 2.2 Nutrition and Food Security

Oral Presentation

Title: **An Income-Based Food Security Indicator for Agricultural Technology Impact Assessment**

Authors: John Antle[1] and R. Adhikari[1]
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Abstract: The primary goal of food security assessment is to develop an indicator that can be constructed with available data, is comparable over time and space, and represents the multiple dimensions of food security. Researchers have developed food security indicators for their assessments but most at the present fall short in adequately gauging food security. In this study, we review some of the commonly used food security indicators, analyze the extent to which these indicators satisfy key criteria, and introduce a food security indicator constructed for use in an economic impact assessment that exhibits a number of desirable properties. This income-based indicator is similar to a consumption-based poverty indicator, as it utilizes an estimate of the income required to purchase a food 'basket' that meets nutritional requirements, and compares this food security income requirement to the household's per capita income. The applicability of the indicator is illustrated with an analysis of the impacts of legume inoculation technology being developed for smallholder farms in Tanzania and other parts of Africa. Combining the TOA-MD model with the proposed indicator, we find a moderate rate of inoculant adoption, and for those that do, an increase in returns, higher income, and reduced food insecurity.

Session 2.3 Biophysical Impacts of Climate Change

Oral Presentation

Title: **What would happen to wheat production in cotton-wheat cropping zone of Punjab under mid century scenario?**

Authors: Ashfaq Ahmad[1], T. Khaliq[2], S. A. Wajid[2], M. Ishfaq[2], S. Tahir[2], S. Ahmad[3], M. Ashfaq[4] and G. Hoogenboom[5]
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Abstract: Wheat is the staple food and contributes nearly 70% of the calorie needs of an average Pakistani. The cotton-wheat belt in the south comprises of 1.36 million ha and grows 45% of the wheat produced in the province. Cotton crops particularly cause serious delays in sowing of wheat. Cotton's growth cycle and favorable price structure may push wheat planting into late December or early January. Down scaling results under RCP8.5 and CCSM4 model (with cool/dry characteristics) suggest a 2.5 °C rise in the maximum and minimum temperatures with 9% decrease in the precipitation amount in the 2040-2069 projected period over the region. The projected increase in temperature and the corresponding decrease in the precipitation regime give clues regarding devastation in the agricultural yield in the 2040-2069 projection period over the region. Well calibrated and validated models DSSAT and APSIM were used to simulate wheat yield at farmers field and found that both models simulated wheat yield well with <10% error. Both the model were run with base line 1980-2010 and then with future generated data with 5 GCMs. Results showed that there will be reduction in wheat yield under future scenarios of RCP8.5 and 4.5. This reduction level is different in different district. However, this reduction about 1% in the current yield.
Key words: APSIM, CERES-Wheat, GCMs, Climate change, RCP 8.5, RCP 4.5

Oral Presentation

Title: **Climate change impacts on crop yield in Koutiala, Mali**

Authors: Myriam Adam[1], A.M. Nenkam[2], M. Diancoumba[2], F. Akinseye[2], P.S. Traore[2], S.B. Traore[3], S. G. K. Adiku[4], and D. S. MacCarthy[4]
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Abstract: An integrated modelling framework is used to simulate crop productivity for current and future climate scenarios. Two crop models, Decision Support Systems for Agro-Technological Transfer (DSSAT) and the Agricultural Productions Systems sIMulator (APSIM), were calibrated and evaluated for the study site in Koutiala, Mali, simulating yields of maize, millet, and peanut for 123 households. These crop models are fed by weather data from baseline climate (1980-2009) from observed weather and futur

Session 2.3 Biophysical Impacts of Climate Change

Oral Presentation

Title: **Sensitivity of current spring barley production system to climate change**

Authors: Davide Cammarano, M. Rivington, K. Matthews, and D. Wardell-Johnson
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Abstract: Climate change will have significant impact on cultivated barley areas in Scotland, modifying the capability of land and thus the potential areas over which cropping activities may be conducted. In this study we evaluate the impact of climate change on simulated barley yield using 4 Global Circulation Models (GCMs), 2RCP (45 and 85), and 2 crop simulation models. The models were calibrated using benchmark variety trials and evaluated on field trial data collected at an experimental farm for spring barley. The models were run on the cultivated barley areas using geospatial datasets of climate land-use/crop management, and soils. Crop models calibration and evaluation showed little variability between models, and their ability to replicated experimental data. Overall, climate change will not have a significant negative impact on spring barley because the increase in temperature at such high latitude is within the optimal range for the cultivar. Future yield is forecasted to increase between 5 to 9% under RCP45 and RCP85, respectively.

Oral Presentation

Title: **Wheat Yield Potential in Europe Under Climate Change Explored by Adaptation Response Surfaces**

Authors: Margarita Ruiz-Ramos[1], R. Ferrise[*2], A. Rodríguez[1], I. J. Lorite[3], Other 27 co-authors[4]
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Abstract: Uncertainty about climate change increases the complexity of addressing adaptation and optimizing risk management at regional level. Approaches for managing this uncertainty, simulating and communicating climate impacts and adaptation opportunities are required.

Here, we applied an ensemble of 8 crop models to identify suitable adaptation options for rainfed winter wheat at Lleida, NE Spain, and analyze the results by constructing adaptation response surfaces. These are plotted surfaces showing the response of an adaptation option compared to the non-adapted simulation in an impact variable (e.g. yield changes) for a range of systematic changes in temperature and precipitation. The general methodology was adapted from Pirttioja et al. (2015). The adaptation options explored were changes in sowing dates, cultivar phenology, supplementary irrigation and combinations of these. A "full irrigation" scenario also served as a reference for identifying yield potentials and associated water requirements.

The results indicated that adaptation strategies may help to reduce detrimental effects of climate change. Combined adaptations performed better than single adaptation options. The best results were obtained when a non-vernalizing cultivar was sown 2 weeks earlier and given 40 mm of supplementary irrigation at anthesis. However, some rainfed only options also shown potential for mitigating climate change impacts.

Our analysis evaluated if the explored adaptations fulfill the biophysical requirements to become practical adaptative solutions. This study exemplified how adaptation options and their responses can be analyzed, evaluated and communicated in a context of high regional uncertainty for current and future conditions and for short to long-term perspectives.

Session 2.3 Biophysical Impacts of Climate Change

Oral Presentation

Title: **Towards Coordinating Assessments of Environmental Sustainability in Agricultural Systems for SDG2**

Authors: Sonali McDermid[1], D. Kanter[1], and C. Rosenzweig[2]
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Abstract: Article 2.4 in Sustainable Development Goal (SDG2) states: "By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters, and that progressively improve land and soil quality". Achieving SDG2 demands a better understanding of those agricultural management practices deemed sustainable in both their biophysical and socio-economic contexts, and continued evaluation of these practices through advanced modeling, empirical measurements, and the development of indicators to monitor progress across varying spatial and temporal scales.

Efforts are underway to coordinate research on the impacts of climate variability and change, and socio-economic development on agricultural production and rural livelihoods. Here, we initiate discussion of a complementary effort to comprehensively assess the environmental and socio-economic sustainability of various agricultural development trajectories, management practices, and adaptations in relation to meeting the needs of SDG2, while further informing the full suite of SDGs. This requires the formation of a coordinated assessment methodology that allows us to quantitatively understand the role of agricultural development in fostering sustainability in the context of current and future climate change.

We suggest a modeling framework for AgMIP that considers, and develops linkages between, water availability and quality; agricultural carbon and nitrogen cycling, inclusive of GHG emissions; and agricultural biogeophysical feedbacks that impact a range of ecosystem services and biodiversity. We envision these efforts will incorporate findings, adaptations, and interactions with integrated assessments of food and nutrition security.

Oral Presentation

Title: **Making climate data useful for decision makers at the local scale: the case of Nkayi district, Zimbabwe**

Authors: Olivier Crespo[1], S. S. Nangombe[2], T. Muhwati[3], P. Masikati[4], S.H.K. Tui[5], E. N. Moyo[3], D. Nyoni[6], and J. Rurinda[7]
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Abstract: The climate change research community recognizes that climate data need to be translated into climate information useful and relevant for various users such as farmers and decision makers. They need context specific answers to increase their adaptive capacity and to allow effective planning. The most common challenge is to provide information on how climate variability and change will affect the current and future production of crops and livestock, and the entire agricultural systems.

The Agricultural Model Intercomparison and improvment Project (AgMIP) supports co-exploration of climate data analysis and climate information needs, with climate scientist and regional stakeholders, to produce useful climate products and services. Through dedicated and iterative engagement with local communities and regional stakeholders we propose dedicated analysis of current and future climate projections, delivered in formats that will help farmers and stakeholders to make better informed decisions.

We present the results for Nkayi district in Zimbabwe. The climate is semi-arid, with dry moderately cold winter and variable low rainfalls during the hot summer, thus high risk for predominantly rain-fed agriculture. Future projections for the area show consistently increasing temperatures, but inconsistent rainfall changes. Local stakeholders are well aware of and mostly suffering those climate changes, but lack the relevant information to face them. Regional climate and crop research institutions, with Zimbabwean Meteorological Services, Climate Change Management and Ministry of Agriculture, with Nkayi and local farming community representatives, started co-exploring and proposing new ways to respond to local needs for climate information. This will contribute to the Impact Explorer (IE), web-based tool dedicated to the dissemination of locally relevant climate information.

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21. *Poster Presentation*

Title: **The Impact of Climate Change on Rainfall and Maize Production in Nakon Ratchasima, Thailand.**

Authors: Jaruwan Heangmanee[1]
[1] University of Southhampton, UK

Abstract: Climate change is not only of concern with regards to environmental change but also in terms of its potential effects on different economic sectors. Agriculture is one such sector, which is extremely sensitive to the weather and water resources and which is being considerably affected by climate change. This research focuses on the impacts of climate change particularly on rainfall in the maize zones of the upper part of the Mun River Basin (Nakon Ratchasima province, Thailand). The projected climate change is derived using downscaled results from the Statistical Downscaling Model (SDSM) and the most recent Decision Centric (SDSM-DC) method, which is used to determine functional and plausible future daily weather data and can substitute for missing data records for calibrated predictor-predictand variables respectively. The National Center for Environmental Prediction (NCEP) re-analysis was selected as the regional predictor variables for the period 1961-2000. In the case of the study area, which is located between two global grid cells, it was necessary to extend to the multiple-site method by interpolation. To assess the impact of climate change on agriculture, maize yields under different environmental impacts were analysed and simulated using the Cropping system tool-CERES-Maize model. To examine rainfall and maize yield interactions, a field experiment was developed in which maize was grown under 15 different treatment combinations that comprised rainfed and irrigated cultivations. Rainfed and irrigated treatments were located in natural conditions whilst rainfall simulation was in the greenhouses. The water requirements for the maize were based on the future rainfall modelled using SDSM. Two treatments simulated the effects of vegetative measurements (green manuring and cover cropping treatments) which reflect both anthropogenic controls on vegetataion and possible vegetative response to climate change.

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22. *Poster Presentation*

Title: **Evaluation of Climate Impact, Adaptation, Vulnerability and Resilience in Agricultural Systems using AgMIP Regional Integrated Assessment Methods**

Authors: Sabine Homann-Kee Tui[1], K. Descheemaeker[2], P. Masikate[3], R. Valdivia[4], and J. Antle[4]
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Abstract: Climate-smart agriculture recognizes that climate impacts and vulnerability of smallholder farming systems must be addressed as part of broader pathways towards sustainable agriculture. Evaluating potential impacts of adaptation technologies can inform transformation of agricultural systems, supporting food security and resilience under climate change. This paper illustrates how AgMIP simulation-based methods can be used for quantifying impacts of adaptation, useful for climate-smart agriculture. We explore trade-offs and performances for a mixed farming system in Nkayi district, semi-arid Zimbabwe, with high vulnerability to changing climate and limited capacity to adapt. Assuming that Zimbabwe will slowly step-up out of its economic crisis and a high emission scenario (RCP 8.5), we tested adaptation options that stakeholders and scientists considered relevant, including integrated soil fertility management, drought tolerant crop varieties and livestock feed. Results suggested that even if impacts of climate change would be moderate on crops and livestock, more than half the farming population would be negatively affected and hence exposed to greater vulnerability, especially those without livestock. The tested adaptations offset the effects of climate change for crops and livestock. They benefited most farms and enhanced their resilience, the magnitude of gains would however be small, with greater gains for larger farms with livestock. The fact that these incremental adaptation options reduced poverty levels for less than 10% of the population is a strong argument for engaging stakeholders in the design of more transformative solutions, including policies, institutional arrangements and social organization, towards solving the complex issues in farming under changing climate.

Session 2.3 Biophysical Impacts of Climate Change

23. *Poster Presentation*

Title: **Impacts of climate change: a sensitivity analysis to understand the role of soil fertility and water on maize in the face of climate uncertainty in semi-arid Zimbabwe**

Authors: Patricia Masikati[1], O. Crespo[2], E. Moyo[3], D. Msendeke[4], J Rurinda[5,6], and K. Descheemaeker[7]
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Abstract: Although climate change would affect various development areas in Zimbabwe, the risk to agriculture is most important, mainstay of the country. There is limited knowledge on impacts of projected increases in CO_2 and temperature on agriculture, changes in precipitation and combined effects on crop production, hence adding to uncertainties surrounding future smallholder farming systems. Biophysical crop models are commonly used to understand the impact of climate change on agricultural systems, investigate crop responses and development of adaptation strategies. We use the Agricultural Production Systems Simulator (APSIM) to assess sensitivity of maize to various aspects of climate change under different soils and management practices in semi-arid Zimbabwe. Results show that maize response to fertilizer reduced with climate change, but response curves varied across soil types and future climate projections. On current soils, which are low in organic carbon content (<0.5 % in top layer) and water holding capacity (<60 mm), the hot-dry scenario resulted in a maximum yield of 1.3 t/ha at a fertilizer application rate of 50 kg N/ha, down from 1.9 t/ha under the current climate. However, on better soils (OC> 0.70 % and PAWC >85 mm) the maximum yield would be >1.7 t/ha at the same application rate and climate conditions. The sensitivity analysis revealed a sudden decrease in grain yield with a mean temperature increase of 2°C, while increased CO_2 resulted in a steady increase of maize grain. Improving soil fertility and water holding capacity have the potential to reduce impacts of climate change on maize production.

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24. *Poster Presentation*

Title: **Climate impacts on crop yields in Central Argentina. Adaptation strategies.**

Authors: Alfredo L. Rolla[1,2], M. N. Nuñez[1,2,3], M. I. O. de Zarate[1,2], E. R. Guevara[4], S. G. Meira[4], G. R. Rodriguez[4], and J. J. Ramayon[5]
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Abstract: In this work the CASANDRA platform was used to make calculations for impacts and adaptations to future climate on regional crop yields of maize, wheat and soybean, considering the Pampas region as study area (that covers an area of 60 million hectares). The climate inputs to the platform were generated from the CCSM4 climate model of National Centre for Atmospheric Research (NCAR, USA), because it was regarded as the best model among others for the present time in the region. Projections from the climate model show for the near future (2015 – 2039) and far future (2075 – 2099) increases of the annual mean of maximum and minimum temperature. Mean annual precipitation will also increase in the near future, while will increase more significantly for extreme emissions scenarios in the far future. The projected impact on crop yields according to the crop model for the near future shows a decrease of wheat yield, while for maize and soybean crop projections shows significant increment compared with the baseline for moderate (RCP4.5) and extreme (RCP8.5) emissions. In the far future, the wheat in the RCP 4.5 scenario the yield decrease, while in the scenario RCP 8.5 increase comparing with the baseline. For maize will increase and soybean will increase significantly for both scenarios. Some adaptation strategies for the near and far future were designed for maize and wheat, resulting in increases up to 45%. In soybean was not necessary design any strategy of adaptation.

Session 2.3 Biophysical Impacts of Climate Change

25. *Poster Presentation*

Title: **Selection of a Representative GCM Subset for Integrated Assessment Modeling**

Authors: Alex C. Ruane[1] and S. P. McDermid[2]
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Abstract: We present the Representative GCM Subset approach developed within the Agricultural Model Intercomparison and Improvement Project (AgMIP) to select a practical subset of global climate models (GCMs) for regional integrated assessment of climate impacts when resource limitations do not permit the full ensemble of GCMs to be evaluated given the need to also focus on impacts sector and economics models. Subsetting inherently leads to a loss of information but can free up resources to explore important uncertainties in the integrated assessment that would otherwise be prohibitive. The Representative GCM Subset approach identifies five individual GCMs that represent the full ensemble of temperature and precipitation change within the growing season while maintaining information about the probability that basic classes of climate changes (relatively cool/wet, cool/dry, middle, hot/wet, and hot/dry) are projected in the full GCM ensemble. We demonstrate the selection methodology for maize impacts in Ames, Iowa, and discuss limitations and situations when additional information may be required to select representative GCMs. We then classify 29 GCMs over all land areas to identify regions and seasons with characteristic diagonal skewness related to surface moisture as well as extreme skewness connected to snow-albedo feedbacks and GCM uncertainty. Finally, we employ this basic approach to recognize that GCM projections demonstrate coherence across space, time, and greenhouse gas concentration pathway. The Representative GCM Subset approach provides a quantitative basis for the determination of useful GCM subsets, and may be extended for application to a range of scales and sectoral impacts.

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26. *Poster Presentation*

Title: **Climate change impacts on maize production in western Mozambique**

Authors: Jairos Rurinda[1,2], A.L. Gungulo[3], P. Masikati[4], O. Crespo[5], and S. H. K. Tui[6]
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Abstract: Climate change and increased climate variability are increasingly recognized as major biophysical sources of vulnerability for maize production and livelihoods in southern Africa. We analyzed the impacts of increasing temperatures and varying rainfall patterns on maize yield in Sussundenga, Mozambique. Multiple climate and crop simulation models were used in the analysis. An ensemble of 5 GCMs representing different climates (cool/wet; cool/dry; dry/wet; and dry/hot) were driven by two representative concentration pathways: RCP 4.5 and RCP 8.5 for the time period, 2040 - 2069. The climate data were inputs for two crop growth models, APSIM and DSSAT, which are widely validated across many areas in southern Africa. Both mean maximum and mean minimum temperatures have increased by between 1.5°C and 3°C and between 1°C and 2°C under RCP 8.5 and RCP4.5, respectively for the period 2040 - 2069 compared with the baseline, 1981 – 2010. The direction of change of mean annual total rainfall is not yet clear although rainfall variability is highly likely to increase. Average maize yield simulated with APSIM declined by 12% under RCP 8.5 and by 5% under RCP 4.5, compared with the baseline climate. The average maize yield simulated with DSSAT declined by 32% under RCP 8.5 and by 28% under RCP4.5. Overall the results suggest that the impacts of climate change on the current low input maize production system are relatively low. Improved crop and soil fertility management practices would be more important than climate change by mid 21st century for increased crop yield and livelihoods in western Mozambique.

Session 2.3 Biophysical Impacts of Climate Change

27. *Poster Presentation*

Title: **Assessing the Yield Gap and resource use efficiency of Maize -A case study in Ethiopia**

Authors: Amit K. Srivastava, T. Gaiser, and F Ewert
Institute of Crop Science and Resource Conservation, University of Bonn, Germany

Abstract: In sub-Saharan Africa, the yields of the major cereal crops have stagnated at less than 25% of potentially attainable yields while the per capita food production has continued to decrease over the last several decades. Major reasons for the yield gap are frequent drought stress and lack of nutrients warranting their efficient use.There is high demand due to scarcity of information on yield gaps, nutrient use efficiency in Ethiopia. Hence, in this study, the yield gap and Agronomic nitrogen use efficiency was estimated for maize (Zea mays L) in Jimma, Bako, and Yayu districts in the Oromia region of Ethiopia, which constitute major maize production areas, based on simulation runs with the SIMPLACE modeling framework. The simulations were run at 25 x 25 km grid cells and yield was calculated for each simulation grid for the period of 13 years (1998- 2010) and aggregated from the simulation grid to the district level for comparing them with the statistics. The yield gap was in the tune of 9700 kg ha-1 and results indicate that 200 kg ha-1 of nitrogen is the optimum application rate across the districts. Yield gaps were mainly due to nutrient limitations (nitrogen and to a smaller extent phosphorous) due to less average nitrogen application rates in this region (i.e., <20 kg N ha-1 Yr-1). Insufficient nutrient application happens because inorganic fertilizers are often too expensive for most of the farmers, whilst organic resources are available in limited quantities.

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28. *Poster Presentation*

Title: **Balancing crop production and groundwater table recovery by cropping system adaptation in the North China Plain**

Authors: Honglin Zhong[1], L. Sun[1], G. Fischer[2], Z. Tian[3], and Z. Liang[4]
[1] Department of Geographical Sciences, University of Maryland, USA, [2] International Institute for Applied Systems Analysis, Austria, [3] Shanghai Climate Center, Shanghai Meteorological Services, China, [4] Hangzhou Meteorological Services, China

Abstract: To guarantee the food security, China has put great efforts on increasing crop production, and great success has been achieved in the last decades. But high crop productivity demands a great amount of water for irrigation, especially in the major cropping region - North China Plain (NCP), where the groundwater is over-extracted to meet the soaring needs from the rapid social-economic development and maintain high agriculture production. Projected climate might exacerbate potential risks as rainf

Session 2.4 Soils and Crop Damage

Oral Presentation

Title: **Accounting for the legacy of soil and crop management when assessing climate change impact on crop production**

Authors: Bruno Basso[1,2]*, B. Dumont[1], I. Shcherbak[2], S. Asseng[3], S. Bassu[4], C. Biernath[5], K.J. Boote[6], D. Cammarano[7], G. de Sanctis[8], J.-L. Durand[9], F. Ewert[10], S. Gayler[11], P. Grace[12], R. Grant[13], D.W. Hyndman[1], J. Kent[14], P. Martre[15,16], C. Nendel[17], E. Priesack[5], D. Ripoche[18], A.C. Ruane[19], J. Sharp[20], P.J. Thorburn[21], J.L. Hatfield[22], J.W. Jones[23], C. Rosenzweig[19], K. Paustian[14]
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Abstract: The impacts of climate change on global and regional crop production are generally based on crop models simulations1-4. If crop models are used to evaluate global food security under climate change5, or to design adaptation6 and mitigation strategies, continuous-time simulations are necessary to capture the changes in soil carbon, water, and nutrients4 along with their effects on crop production. To evaluate the long-term impacts of soil and crop management strategies on crop production under climate change, we performed the largest multi-model ensemble study using continuous simulations in maize-fallow and wheat-fallow rotations in eight sites across the globe. Significant differences in both crop yield and soil nitrate accumulation were found between simulations with continuous vs annually reinitialized modes under scenarios with increasing temperatures. We found that within the ensemble results of continuous simulations, the majority of models agreed with respect to the direction of the changes for wheat and maize grain yields, and for soil organic carbon and nitrates under increased temperatures. The decline of soil carbon with increasing temperatures poses additional threats to crop yields exacerbating the negative effects of climate change on food security and environmental degradation. These findings highlight the critical role of soil and the importance of including dynamic appropriately considering soil property changes over time to assess climate change impacts on food production and to formulate adaptation and mitigation strategies.

Oral Presentation

Title: **Soil/land quality and health modeling within RASLEV framework in conditions of Russia agroecosystems**

Authors: Ivan I. Vasenev
Russian Timiryazev State Agriculture University (RTSAU), Russia

Abstract: Rural region sustainable development demands agroecosystem service-driven land-use planning and decision making based on the quantitative analysis, modeling and prediction of agroecosystems' soil quality and health, their principal agroecological functions.

Agroecologically smart land management refers to sustainable balance among 7 principal groups of soil/land agroecological functions: (a) Agroclimatic ones of plant supply with PAR, effective heat and available moisture; (b) Agrochemical functions of crop supply with available nutrients; (c) Agrophysical ones of favorable conditions for farming workability and trafficability; (d) Hydrophysical functions of plant seasonal supply with available moisture; (e) Phyto-sanitary functions of favorable condition for crop minimum damage by pathogens, pests and weeds; (f) Ecogeochemical ones of soil resistance to contamination; (g) Ecopedomorphogenetic functions of plant and farming support with soil agroecological quasi-homogeneity in space and time.

Realized in RASLEV and ACORD-R (RF registration #2012612944) integral algorithm of soil/land current and predicted quality and health evaluation/ modeling includes 4 particular ones: (i) principal agroecological parameters assessment by their logistic modelling adapted to concrete soil/land; (ii) agroecological functions assessment as corrected harmonic mean from their parameter assessments; (iii) homogeneous soil/land map units assessment as combination of their functions values; (iv) heterogeneous soil/land map units assessment as weighted average value corrected by soil cover patterns contrast and boundary complexity.

The carried out under RF President grant NSc-10347.2016.11 and 7FP grant # 603542 long-term agroecological research of representative agrolandscapes allow essentially improve their soil/land quality and health evaluation, with especial attention on regional and within-field variability of land agroecological and environmental functions.

Session 2.4 Soils and Crop Damage

Oral Presentation

Title: **Pathways to Nitrogen's Planetary Boundary**

Authors: David R. Kanter[1], and J. D. Sachs[2]
[1] New York University and Columbia University, [2] Columbia University

Abstract: Nitrogen pollution is one of the most important environmental issues of the 21st century, contributing to air and water pollution, biodiversity loss, climate change and stratospheric ozone depletion. While the planetary boundary for nitrogen is one of two that humanity has exceeded, it has yet to garner the attention from the policy community that it deserves. Moreover, emerging calls for a coordinated international response to nitrogen pollution need to be reconciled with the reality that solutions, particularly in the agricultural sector, are often locally specific. This is the goal of the new "Pathways to Nitrogen's Planetary Boundary" project (PNPB): disaggregating nitrogen's planetary boundary into several regional boundaries, and developing pathways to reach these boundaries using regionally-tailored nitrogen use efficiency strategies. This new form of regional integrated assessment aims to provide a roadmap for policy-makers to better address nitrogen pollution. It also adopts a form of scenario development seldom used in environmental modeling: "backcasting" technical pathways to achieve a future goal (nitrogen's planetary boundary), instead of forecasting multiple futures from a common present.

The regional teams (East Asia, South Asia, East Africa, Eastern Europe, Latin America and North America) have already been formed as part of the International Nitrogen Management System initiative. Their focus on improving understanding of regional nitrogen flows is a crucial first step for developing the regional boundaries and pathways. PNPB would provide a forum for sharing methods, tools, data, and results among the teams, and ultimately aggregate the pathways to determine the extent to which they meet nitrogen's planetary boundary.

Oral Presentation

Title: **Impacts of crop rotation, extreme weather events, crop growth and residue management on soil organic carbon content**

Authors: Anne Gobin
Flemish Institute for Technological Research

Abstract: The aim was to quantify the impacts of crop rotation and crop growth on soil organic carbon content at the regional scale with test case Flanders in Belgium. A framework for modelling the impacts of crop growth on soil organic carbon content was developed by coupling the dynamic process-based crop growth model REGCROP (Gobin, 2010) to the RothC carbon model (Coleman and Jenkinson, 1999). A geo-database covered all parcels and 15 years of crop rotation in Flanders. Crop allometric algorithms were developed from variety trials for common crops in Flanders. Crop residues and manure management were used to derive stable organic matter fluxes to the soil.

Results indicate that crop growth and rotations influence soil carbon to a very large extent. Crop residues of grain maize and winter wheat followed by catch crops contribute most to the total carbon sequestered in agricultural soils. Carbon sequestration is highest under wet and relatively cold weather conditions. For the same rotations carbon sequestration is estimated highest on clay soils and lowest on sandy soils. An extensive sampling in farmers' fields revealed that soil characteristics other than soil texture played an important role (Van de Vreken et al., 2016), and improved the simulations. Agricultural practices and land management influence soil carbon.

The research is funded by the Belgian Science Policy Organisation (Belspo) under contract nr SD/RI/03A.

Session 2.4 Soils and Crop Damage

Oral Presentation

Title: **Modeling intercropping with cereals in smallholder agrosystems. From lessons learned in central Brazil to their application in the Peanut Basin in Senegal**

Authors: Alpha Bocar Baldé[1], L. Tall[2], N. Bakhoum[2], F. Affholder[3], C. C. Dauphin[4], M. Corbeels[5], N. Kane[2], D. Masse[6], and E. Scopel[3]
[1] ISRA, Centre National de Recherches Agronomiques, Senegal, [2] ISRA, Laboratoire National de Recherches sur les Productions Végétales, Senegal, [3] CIRAD, France, [4] LEMSAT (IRD-ISRA-UCAD), Senegal, [5] CIMMYT, ICRAF House, Kenya, [6] UMR210 ECO&SOLS (IRD/Montpellier SupAgro/Cirad), France

Abstract: In most areas of sub-humid tropics where the rainy period is too short to allow a system with a succession of crops, intercropping is an option to diversify culture and enhance agrosystems resiliency. However, interactions among associated crops (facilitation and/or competition) are complex, variable in time and will depend on the characteristics of each crop and the management of the whole system. Understanding and quantifying these complex interactions and their impacts on the agrosystem productivity require to consider temporal dimension. In fact, one-off measures or entirely experimental approach cannot adequately answer these questions. However, crop modeling can complete experimental approaches by taking better account of changing interactions over time, allowing dynamic quantification of the flow of resources and their distribution. We will present an example of intercropping model with maize using STICS-CA model, adjusted calibrated and then evaluated for the Brazilian Cerrado system. We will then discuss on how to use a similar approach for millet-cowpea intercropping systems in the Senegalese peanut Basin.

Oral Presentation

Title: **Soil organic matter and sensitivity to climate change. Can we disentangle correlation and causation?**

Authors: Jean-François Soussana, F. Ehrhardt, and the modeling consortia of the AGMIP grassland activity and GRA soil C-N group*
INRA, Paris, France

Abstract: About half of the agricultural soils are degraded. Erosion of agricultural land would cause emissions of 0.3–1.0 Gt C/yr and the annual cost of fertilizer to replace nutrients lost to erosion would be US $ 110 – 200 billion. Soil restoration through increased soil organic matter content has potential for reducing yield variability and for both climate change adaptation and mitigation. This potential will be explored by the 'Soils for food security and climate, 4 per 1000' initiative of COP21 through an international research program in close collaboration with AgMIP and with the GRA (Global Research Alliance on agricultural greenhouse gases). In this context, we will present first results of a model inter-comparison exercise testing the predictive ability of simulation models for both soil organic carbon (SOC) stocks and yields in arable crop rotations and temperate grasslands. A total of 24 models used in 11 countries for the prediction of GHG emissions in crop and grassland systems are contributing. The study has been set up with five successive steps that gradually release information to the modeling groups, ranging from fully-blind application of the models to complete availability of the experimental measurements. Here, we present results showing modeling uncertainties for SOC stock changes, with comparisons to observed data in the case of grassland experiments. Moreover, the sensitivity to climatic drivers of calibrated models has been analyzed within the AgMIP livestock and grassland group and projections of climatic impacts on yields and soil carbon are shown. From these first results, we discuss how to systematically test through modeling the role of soil organic matter for changes in crop yields and in sensitivity to climate change. We also speculate that simulation models could in the future be used to disentangle between correlation and causation in plant-soil relationships leading to improved crop and pasture adaptation to climate change when soil organic matter is high.

Session 2.4 Soils and Crop Damage

29. *Poster Presentation*

Title: **Management of N fertilizer to sustain winter wheat yield in response to climate change: case study for eastern Austria**

Authors: Elnaz Ebrahimi[1], A. M. Manschadi[1], J.Eitzinger[2], and H.-P. Kaul[1]
[1] University of Natural Resources and Life Sciences, Dept. of Crop Sciences, Division of Agronomy, Tulln, Austria e-mail elnaz.ebrahimi@boku.ac.at, [2] University of Natural Resources and Life Sciences, Dept. of Water - Atmosphere - Environment, Institute of Meteorology, Vienna, Austria

Abstract: It has been estimated that without the input of N fertilizer, only about half of the current global population's food could be supplied based on soil organic N. Crop N fertilizer requirement depends on soil N supply and crop N demand. To optimize N fertilizer rate, adjustment of application time with wheat phenological development plays a key role to increase economic yield production while reducing the detrimental environmental impacts of N losses from agricultural fields. Therefore a simulation study was set up to assess the optimum N fertilizer in terms of rate and time of application under future climate. Previously evaluated APSIM was run with 100-year stochastic daily weather series for baseline (BL, 1981-2010) as well as those generated by the two Global Circulation Models (IPCM4 and MPEH5) under either A1B (536 ppm CO_2) or B1 (490 ppm CO_2) emission conditions. A factorial combination of nitrogen fertilizer (N) and sowing date (SD) treatment was used for simulation runs. N fertilizer in the ratios of 80, 120, 160, and 200 kg N ha^{-1} was applied for wheat sown on Sep 20, Oct 20, and Nov 20. Simulated wheat yields under climate change scenarios varied substantially among the two GCMs. Wheat yields under IPCM4 projections were reduced by 29 and 32% with low or high emissions, respectively. Under future climatic conditions, maximum wheat yields were predicted when crops are sown early (Sep 20) with 160 kg N ha^{-1} applied at earlier dates than the current practice.

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30. *Poster Presentation*

Title: **Comparing two models of the diurnal temperature cycle for the simulation of crop and pest phenology under climate change**

Authors: Raphael Felber[1], J. Fuhrer[1], S. Stöckli[2], and P. Calanca[1]
[1] Agroscope, Climate and Air Pollution, [2] Research Institute of Organic Agriculture (FiBL)

Abstract: Air temperature is the most important determinant of crop and pest phenology. The total amount of heat required for an organism to develop from one point to another in its life cycle is calculated as degree-days. Organisms do not respond to global averages but rather to regional settings and their variations in time at hourly scale. However, as climate models do not provide reliable information at high temporal resolution, statistical or empirical models are needed to generate hourly temperature data for assessing crop and pest phenology under climate change.

We present the comparison of two approaches for generating hourly temperatures from daily values of minimum (Tmin) and maximum (Tmax) temperature. The statistical downscaling approach proposed by Hirschi et al. (2012) uses a nearest neighbour re-sampling procedure to prescribe realistic diurnal cycles constrained on the observed or simulated Tmin and Tmax. The model of Parton and Logan (1981) assumes a truncated sine wave for daytime and an exponential function for night-time temperatures. It was modified to reduce the overestimation of daytime growing degree-day sums and obtain smooth transitions between two consecutive days.

The performance of the two approaches was tested with observed data and climate scenarios for Switzerland. To illustrate the potential for application, we discuss the prediction of phenological stages of the codling moth (Stoeckli et al., 2012), a common apple pest.

Hirschi, M., et al., Earth System Dynamics, doi:10.5194/esd-3-33-2012, 2012.
Parton, W.J. and Logan, J.A.: Agricultural Meteorology, doi:10.1016/0002-1571(81)90105-9, 1981.
Stoeckli, S., et al., PLoS ONE, doi:10.1371/journal.pone.0035723, 2012.

Session 2.4 Soils and Crop Damage

31. *Poster Presentation*

Title: **The efficacy of crop rotations and nutrient management in maintaining farmer livelihood and ecosystem services: a case study from Madhya Pradesh, India**

Authors: Sonali McDermid[1], M. Mohanty[2], and P. Mondal[3]
[1] New York University, USA, [2] Indian Institute of Soil Science, India, [3] Columbia University, USA

Abstract: Low-input, diversified, smallholder farming systems in central India are subject to large monsoonal rainfall variability, rising surface temperatures, and significant socio-economic inequalities, all of which threaten regional food and nutrition security. At the same time, there is a need for smallholder systems across India to rehabilitate degraded soils, build organic matter content and retain nutrients within cropping systems. We present preliminary findings from a new climate-crop modelling effort to understand how current and future climate variability will impact crop productivity and cropping system nutrient cycling under a variety of feasible crop rotations and nutrient management regimes. APSIM crop model results are shown for sites in three districts, Balaghat, Dindori, and Mandla, in Madhya Pradesh, India, where we vary over a series of potential crop rotations to ascertain which systems provide a multi-optimum of crop productivity, soil carbon enhancement, and decreased nitrogen loss over long-time scales (1980-2010). In addition to testing multiple crop rotations, we also vary over a select range of organic and synthetic nutrient application amounts and timing to reflect current recommendations for smallholders in these locations, and proposed alternative applications thought to retain and enhance important agro-ecosystem services. We test the efficacy of these systems – combined crop rotation and nutrient management - to maintain and increase productivity while minimizing nutrient loss under both current and future climate conditions, and via a series of carbon-temperature-water sensitivity tests, following methods specified in protocols for the AgMIP Regional Integrated Assessments and the Coordinated Climate-Crop Modeling Project.

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32. *Poster Presentation*

Title: **The modelling approach for describing productive and fertility dynamics in long-term experiments**

Authors: Domenico Ventrella and L. Giglio
Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria (CREA) - Unità di ricerca per i sistemi colturali degli ambienti caldo aridi (CREA-SCA)

Abstract: A long-term experiment comparing different crop residue (CR) managements was established in 1977 in Foggia (Apulia region, southern Italy) with the objective to investigate the long-term effects of different types of crop residue management on main yield response parameters in a continuous cropping system of winter durum wheat (DW). The experimental design was a randomized block with five replicates and 8 CR treatments based on burning and incorporation of CR into the soil with and without N fertilizer and irrigation submitted to a one-year rotation of winter durum wheat characterized by a sequence of different cultivars (Valgerardo, Appulo, Latino, Appio, Simeto, Ofanto) adopted every 4 years. In this paper we present the main results of a modeling calibration based on dynamics of yield and soil organic carbonic. DSSAT model (vers. 4.5) was calibrated and validated for each cultivar. The results of simulation was evaluated in terms of statistic indicator: root mean square error, modeling effiency, index agreement and regression analysis between simulated and measured data of phenological data, yield, grain protein content and soil organic carbon (SOC).

The calibration and validation results were different for the different cultivars with the RMSE ranging from 10 to 40% while DSSA was able to simulate the analyzed dynamics of SOC that didn't show a particular increasing or decreasing trend in a period of 26 years.

This study was conducted in the context of the IC-FAR project (prot. 2010FRE7J4, PRIN Funding scheme of the Italian Ministry of Education, University and Research, 2010–11) and "Modelling European Agriculture with Climate Change for Food Security" (MACSUR2) knowledge hub within JPI-FACCE, decree n. 24064/7303/15 of Italian Ministry for Agricultural, Food and Forestry Policies.

Session 2.4 Soils and Crop Damage

33. *Poster Presentation*

Title: **Biotic constraints in APSIM: modelling wheat yield loss in the presence of P. thornei populations.**

Authors: Jeremy Whish[1] and J. Thompson[2]
[1] CSIRO Agriculture, Australia, [2] University of Southern Queensland, Australia

Abstract: Pratylenchus thornei is a major pathogen of wheat crops in the northern grain region of Eastern Australia with an estimated annual yield loss of $38 million. Damaged crops show symptoms of water and nutrient stress and this has been shown to be the result of nematode damage affecting water and nutrient uptake.
The Agricultural Production Systems sIMulator (APSIM) uses the parameter (kl) to describe the root length density and rate of solute uptake from the soil. Adjusting (kl) in response to the size of the P. thornei population at sowing was able to model the observed crop responses of reduced leaf area and delayed water uptake within intolerant wheat cultivars.

The success of this approach to reproducing the observed data, highlights that (kl) will be a suitable coupling point to link the DYMEX created nematode population model and APSIM crop models.

Session 2.5 Crop Model Improvement and Genetics Applications

Oral Presentation

Title: **Toward Next Generation Gene-based Crop Models: Implications on Experiments, Data, Modeling, and Modularity**

Authors: James W. Jones[1], C.E. Vallejos[2], K. J. Boote[1], M. J. Correll[1], S.A. Gezan[3], C. H. Porter[1], G. Hoogenboom[1], and M. Donatelli[4]
[1] Agricultural and Biological Engineering Dept., University of Florida, USA, [2] Horticultural Sciences Dept., University of Florida, USA, [3] School of Forest Resources & Conservation, University of Florida, USA, [4] Council for Agricultural Research and Economics (CREA), Italy

Abstract: Studies have shown that some dynamic plant processes can be modeled to depend on genes (G), the environment (E), and GxE interactions. Most notably, phenological development of plants has been modeled by taking into account gene networks, RNA synthesis, and expression of first flower. However, prior research has been based primarily on empirical approaches to simulate the consequences of G, E, and GxE for processes such as first flower appearance, node addition rate, etc. Whereas one might argue that it is more desirable to model E responses as a function of G, we suggest that the two should coevolve. Characterization of dynamic plant functional E responses by specific G, including GxE, can lead to the discovery of underlying mechanisms using increasingly large genetic and phenotypic datasets. Furthermore, models developed from large datasets show promise for improving assumptions used in existing crop models. We use a bean dataset with 180 recombinant inbred lines grown over 5 environments to demonstrate that assumptions used in existing models about variations among genotypes may be wrong. We also show that development of process-oriented modules can improve previously used functional relationships, and that these modules can replace components in existing models. We focus on models for two different dynamic processes: Leaf Appearance Rate and Progress toward Flowering. Extending this effort to other crops and processes will contribute to next generation crop models. Implications of this approach on experiments, data collection, modeling processes, and modularity in crop models are discussed.

Oral Presentation

Title: **High-throughput phenotyping platform reveals genetic variability and quantitative trait loci of light-related parameters in maize models**

Authors: Tsu-Wei Chen[1,2*], C. Fournier[1,3], S. Artzet[1,3], N. Brichet[1], J. Chopard[1,3], C. Pradal[3], S. Alvarez-Prado[1], L. Cabrera-Bosquet[1], C. Welcker[1], and F. Tardieu[1]
[1] INRA, France, [2] Institut für Gartenbauliche Produktionssysteme, Leibniz Universität Hannover, Germany, [3] CIRAD, France

Abstract: Radiation interception efficiency (RIE) and radiation use efficiency (RUE) are the main driving forces of dry mass accumulation in many crop models, so parameters related to RIE and RUE, e.g. light extinction coefficient (k) and photosynthetic parameters, have strong influences on the results of simulations. In this work, we propose a new method to estimate the RIE- and RUE-related parameters in maize models by a high-throughput phenotyping platform, PHENOARCH (https://goo.gl /x3C6oN), where images of 330 maize lines were taken and used to reconstruct the 3D-structure of the plants. The 3D plants were used to construct a virtual canopy to calculate RIE based on the RATP light model. Leaf area index (LAI) was estimated by the reconstructed 3D-structure and k was calculated from RIE and LAI. Relationship between RIE and plant developmental stage was fitted to a sigmoidal function with three parameters: maximum RIE (RIEmax), maximum change of RIE (smax) and time taken to reach smax (ts). Between genotypes, significant differences in k, RIEmax, smax and ts were found and genome wide association analysis revealed 16 QTL for k, 77 for RIEmax, 1 for smax and 7 for ts. Further parameters including RUE and relative canopy photosynthetic capacity can be also estimated by our method. We conclude that 3D-structure of plants reconstructed in a phenotyping platform can be used to discover the genetic variability of light-related parameters for crop models.

Session 2.5 Crop Model Improvement and Genetics Applications

Oral Presentation

Title: **A basic approach to predicting yields and optimizing inputs using artificial neural networks**

Authors: Paul Koch
Unaffiliated. The work based on on dissertation research completed in 1993 at the University of Nebraska.

Abstract: The purpose of this research was to investigate the degree to which a feedforward artificial neural network (ANN) with error back-propagation could model the relationship between water inputs and yield in a selected crop. At the outset of the effort, the number of crop growth scenarios needed to develop a useful ANN was unknown and presumed to be quite large, perhaps even prohibitively so. In the interest of reaching some useful conclusions about ANN performance and data requirements expeditiously, multiple scenarios were initially generated using the mechanistic crop growth model CERES-Maize. The resulting data sets were then used to train and test ANNs in various configurations. An ANN was found to model simulated scenarios satisfactorily, and a further effort was undertaken to develop an ANN from a small set of available field data alone. Results generally showed that the ability of an ANN to model the relationship between water input and yield was highly dependent upon the interval over which the inputs were summed. A summation interval of six days was found to be optimal or nearly so. ANNs that gave better yield predictions demonstrated expected intraseasonal variations in sensitivity to the amount of water provided. Further tests with the models demonstrated how ANNs might be employed to optimize the delivery of limited inputs across a growing season.

Oral Presentation

Title: **Importance of crop management for simulating crop phenology in large scale impact assessments**

Authors: Ehsan Eyshi Rezaei[1,2], S. Siebert[1], and F. Ewert[3]
[1] Institute of Crop Science and Resource Conservation, University of Bonn, Germany, [2] Center for Development Research (ZEF), Germany, [3] Leibniz Centre for Agricultural Landscape Research, Institute of Landscape Systems Analysis, Germany

Abstract: Phenological development is one of the most important processes influencing crop growth and yield. The responses of phenology to changes in climate and management (mainly sowing date and variety) are well documented. However, most studies have not considered crop management adequately. Crop models are often set up for current management conditions ignoring long-term past and future changes in management. Here we quantify the effects of change in management on phenology simulations of winter rapeseed and winter rye based on 54 years (1960-2013) observations across Germany. The crop model SIMPLACE<Phenology> was applied at a resolution of 1 km × 1 km. We show that long-term changes in phenology trends are crop specific. The observed trend of advancement in the flowering stage of winter rapeseed is 30% steeper in comparison to the trend in the heading stage of winter rye. The crop model, which is calibrated based on observations for the last 10 years of the study period, was not able to reproduce the observed trend of flowering of winter rapeseed through the entire 54 year period, In contrast, the crop model results reproduced well the observed declining trend of heading date in winter rye. The documented changes in cultivars and management practices such as planting density of winter rapeseed were identified as the main reasons of the poor model performance. We conclude that it is essential to account for changes in crop management (especially cultivar change) in climate change impact assessments and that differences among crops need to be considered.

Session 2.5 Crop Model Improvement and Genetics Applications

Oral Presentation

Title: **Assessing agricultural practices in highly variable environments: SARRA-H spatialized crop model for West Africa**

Authors: Mathieu Castets[1], C. Baron[1], S.B. Traore[2], C. Jahel[1], H. Songoti[2], P. Degenne[1], A. Alhassane[2], and D. Lo-Seen[1]
[1] CIRAD, UMR TETIS, Montpellier, France, [2] AGRHYMET, Niamey, Niger

Abstract: In West Africa, environmental conditions that are highly variable in space and time, in particular due to climate, impose heavily constrained choices on agricultural practices. At large scale, this variability is expressed by an annual rainfall distribution that ranges from more than 1200 mm in the Guinean Zone with double rainy season, to almost no rainfall in a single rainy season near the Sahara. This large spatial variability is also expressed at finer scales due to the stormy character of rainfall events. The length of the rainy seasons, the distribution of rainfall events and their intensity within the season all show that the variability is also temporally very large.

During the course of the season, it is essential to take into account differences in agricultural practices while assessing potential productions at different spatial scales. The integration of the SARRA-H crop model in the spatial dynamics modelling platform Ocelet offers new opportunities for this assessment. Processes can be modelled at different spatial and temporal scales and multiple data sources, including vector and raster formats, can be managed efficiently. A working prototype has been developed and is being tested during the 2016 crop season at the AGRHYMET Regional Centre in Niamey, in the framework of its Food Security Early Warning System. The objective of this presentation is to show the crop monitoring capabilities of the spatialized version of the SARRA-H crop model that integrates common agricultural practices at the scale of West Africa.

Oral Presentation

Title: **Improved functions for simulating crop water use are necessary to simulate the impact of [CO_2] on maize yields**

Authors: J.L. Durand[1], K. Delusca[1], K. Boote[2], J. Lizaso[3], R. Manderscheid[4], H.J. Weigel[4], A.C. Ruane[5], C. Rosenzweig[5], J. Jones[2], L. Ahuja[6], S. Anapalli[6], B. Basso[7], C. Baron[8], P. Bertuzzi[9], C. Biernath[10], D. Deryng[11], F. Ewert[12], T. Gaiser[12], S. Gayler[13], F. Heinlein[10], K.C. Kersebaum[14], S.H. Kim[15], C. Müller[16], C. Nendel[14], A. Olioso[17], E. Priesack[10], J. Ramirez[18], K. Waha[16], D. Ripoche[9], E. R. Rötter[19], S. Seidel[20], A. Srivastava[12], F. Tao[21], D. Timlin[22], T. Twine[23], Wang[24], H. Webber[12], and Z. Zhao[25]

Abstract: Past increasing trends in maize yields observed around the world are at risk of slowing down due to rising temperatures and reduced water availability. However, the impact of increasing [CO_2] on maize remains uncertain. FACE studies report significant positive responses to CO_2 of maize yields (and other C4 crops) under dry conditions only. The aim of this work was to compare the simulations of different models using input data from a FACE experiment conducted in Braunschweig during 2 years under limiting and non-limiting water conditions. Twenty modelling groups using different maize models were given the same instructions and input data. Following calibration (cultivar parameters) under non-limiting water conditions and under ambient [CO_2] treatments of both years, simulations were undertaken for the other treatments: High [CO_2] (550 ppm) 2007 and 2008 in both irrigation regimes, and DRY AMBIENT 2007 and 2008. Only under severe water deficits did models simulate an increase in yield for CO_2 enrichment, which was associated with higher harvest index and, for those models which simulated it, higher grain number. However, the CO_2 enhancement under water deficit simulated by the 20 models was 20 % at most and 10 % on average only. As in the experiment, the simulated impact of [CO_2] on water use was negligible, with a general displacement of the water deficit toward later phases of the crop along with longer green leaf area duration at reduced transpiration rate.

Session 2.5 Crop Model Improvement and Genetics Applications

34. *Poster Presentation*

Title: Crop model simulation slants for predicting and managing the climate risks in poor rainfed rice-wheat eco-system of Mid-Western Nepal: application of APSIM, DSSAT model and trade off economic analysis

Authors: Rajendra Darai[1], D.B.T. Magar[2], N. Subash[3], G. Baigorria[4]
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Abstract: The Agriculture is the life line of Nepalese people which contributes to more than 34 % GDP and employing > 65% of total population. In Nepal, agriculture sector is in small fragmented subsistence rainfed farming system, must therefore be a special area of plan focus on other priorities such as resource use efficiency and technology to ensure sustainability of natural resources, adaptation to climate change and improvements in total factor productivity. Obviously Nepalgunj, Banke district is the hub for mid and far western development region of Nepal. Whatsoever it is the hottest place of Nepal with temperature rising well above 46°C in the summer, while minimum temperature goes down to 5°C or even below during the winter season. Annual average rainfall ranges from 1000mm to 1500mm in the district. The rice-wheat cropping system is currently practiced on about 0.5 million hectare of prime agricultural land in terai and lower basin of mid hills of Nepal. Both of the crops are grown in diverse agro-ecological environments and also seasonal diversity (rice-summer & wheat-winter) from terai to hills. All five GCMs predicted higher mean monthly maximum and minimum temperatures during the mid-century period (2040–2069) under RCP8.5 compared to the baseline (1980–2010). However, rainfall projections are reduction trends in all GCM predictions except GCM IIXA. Both APSIM and DSSAT simulated higher wheat and rice yields compared to survey data after the cumulative probability level except one GCM. Moreover, DSSAT simulated higher rice yields than did APSIM. Differences between the DSSAT and APSIM projections are due to differences in sensitivity of the crop models to increases in CO2 and temperature. In the case of rice, out of the 20 GCMs there is an 80% positive response both in DSSAT-rice and wheat projected a pessimistic scenario. Overall, DSSAT simulated more optimistic projections than APSIM for wheat. The integrated assessment result in DSSAT showed that mean yield o

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35. *Poster Presentation*

Title: **Modeling the effects of genotypic and environmental variation on maize phenology**

Authors: Kofikuma A. Dzotsi[1], M. Tollenaar, S. Kumudhini, et. al.
[1]The Climate Corporation

Abstract: Crop phenology is a critical component of yield prediction because it affects the duration of growth and the timing of growth partitioning. Changes in maize genetic and crop-management technologies during the past three decades, such as increased duration of the grain-filling period in North American Corn-Belt maize hybrids, have led to significant yield improvement with phenology traits of new hybrids different from those of older hybrids. As the use of crop models in the assessment of global productivity in response to climate change becomes increasingly popular, limitations of simulation models developed 20 - 30 years ago (e.g. CERES-Maize) in describing the genotypic variation of maize hybrids across a wide range of relative maturities and environments has led to site-specific model calibration with the associated risk of compensation of model errors.

To overcome some of the limitations of the phenology routines in current process-based maize models, a maize model improvement effort was started by the AgMIP maize team. This effort involves the development of a new crop model called AgMaize that includes improved modeling approaches of the main crop processes. This poster introduces the phenology component of AgMaize and presents results of model performance comparison with CERES-Maize of DSSAT based on selected datasets shared through AgMIP.

Session 2.5 Crop Model Improvement and Genetics Applications

36. *Poster Presentation*

Title: **Enhancing EcoMeristem model to better predict rice crop performance in response to increasing atmospheric CO_2 concentrations**

Authors: Damien Fumey[1], D. Fabre[2], L. Rouan[2], and D. Luquet[2]
[1] ITK, France, [2] CIRAD, France

Abstract: Atmospheric CO_2 is expected to reach near 800 ppm in 2100, accompanied by a rise of temperature. This will considerably impact crop performance due to a direct impact on leaf C assimilation, and finally on yield components' elaboration (tillering, leaf area, panicle number, grain filling). Making crop models more predictive in future climate scenario is essential and implies firstly to better simulate the C gain generated by photosynthesis response to CO_2. Crop models commonly compute biomass production using light interception (εi) and use (εb) efficiencies (Monteith's approach). Few of them consider for so key crop architectural traits, leaf photosynthesis and stomatal conductance. EcoMeristem is a functional-structural crop model, simulating cereals' plant growth and phenotypic plasticity at the organ level in response to plant C and water status. It is thus relevant to capture yield components' regulation by climate parameters, particularly CO_2. However it was initially developed using εi and εb. Also, a light interception model accounting for key crop architectural parameters and leaf photosynthesis model inspired from FvCB model accounting for key climate change and leaf parameters, were recently implemented and confronted to experimental data on rice.
This study aims to compare the original and the novel version of EcoMeristem in the way they simulate the regulation of yield elaboration for a few morphologically contrasted rice genotypes in response to radiation, temperature and CO_2. Sensitivity analyses and simulation results will be presented and discussed with respect to the challenge of using crop modelling to support breeding in climate change context.

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37. *Poster Presentation*

Title: **Modeling sorghum and millet genotypes responses to several fertilizer applications in order to optimize fertilizers use according to climate**

Authors: Kyky K. Ganyo[1], B. Muller[2,1], G. Hoogenboom[3], and M. Adam[2,4]
[1] ISRA-CERAAS, Sénégal, [2] CIRAD France, [3] University of Florida, USA, [4] INERA, Burkina Faso

Abstract: In Sahelian and Sudano-Sahelian areas rainfall uncertainty together with poor soil fertility strongly affect productions of millet and sorghum which are the main staple foods as elsewhere in the semi-arid tropics of Asia and Africa. However recent researches have shown that meteorological information and forecasts could help to improve cereal production by allowing providing pertinent advises about sowing dates and inputs use. In particular coupling weather forecasts with crop models to simulate crop responses to different fertilization strategies might help to define the right moments for fertilizer applications.

Hence, we must improve our knowledge about Sahelian and Sudano-Sahelian millet and sorghum genotypes responses to different fertilizations patterns and crop simulation models capability to correctly simulate those Genotype*Water*Fertilizer interactions (GxWxF). That will then allow us assessing the impacts (virtual experiments) of different fertilization practices according to rainfalls seasons patterns.
The main objective of this research is to capture those G*W*F interactions for some contrasted millet and sorghum West-African varieties with DSSAT Cropping System Simulation model, and then to develop fertilization recommendations for farmers according to weather forecasts. The study relies on a set of agronomical trials in Senegal carried out in different locations with respectively 4 and 2 contrasted sorghum and millet genotypes submitted to 5 fertilization modalities derived from standard recommended one and including 2 unconventional late fertilizer applications.

First results from the 2015 trials (first year) will be presented at the conference as well as preliminary results from DSSAT calibration. These results will help to identify potentials improvements for the model.

Session 2.5 Crop Model Improvement and Genetics Applications

38. *Poster Presentation*

Title: **Effect of rainfall variability on the crop growing season characteristics: case of smallholder farming in Zimbabwe**

Authors: Hillary Mugiyo
[1] University of Zimbabwe

Abstract: Rain-fed maize production has significantly declined in Zimbabwe especially in semi-arid and arid areas causing food insecurity. Erratic rainfall received associated with mid-season dry spells largely contribute to low and variable maize yields. This study involved a survey of current farmers' cropping practices, analyses of climatic data from remote sensed data (daily rainfall and daily minimum and maximum temperature) of Wedza station and simulation of maize yield response to climate change using DSSAT crop growth simulation model. The climatic and maize yield data was analyzed using mean correlation and regression analyses to establish relationships between rainfall characteristics and maize yield in the study area. Survey results showed that maize was the staple food grown by 100% of the farming households while 8.7% also grew sorghum. The survey concludes that 56.2% of the farmers grew short season cultivars, 40.2% medium season cultivars and 3.6% long season cultivars. The result of the correlation analysis of climatic data and maize yield showed that number of rain days had strong positive relationship ($r = 0.7$) with maize yield. Non-significant yield differences ($p > 0.05$) between maize cultivar and planting date criteria were obtained. Highest yields were obtained under the combination of medium season maize cultivar and the DEPTH criterion in all simulations. The range of simulated district average yields of 0.4 t/ha to 1.8 t/ha formed the basis for the development of an operational decision support tool (cropping calendar). The study recommends the application of climate smart agriculture techniques.

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39. *Poster Presentation*

Title: **Effect of planting dates on tillering of local varieties of sorghum in Burkina Faso, West Africa.**

Authors: Moussa Sanon[1], G. Hoogenboom[2], S.B. Traoré[3], and L. Somé[1]
[1] Institut de l'Environnement et de Recherches Agricoles (INERA), Burkina Faso, [2] Department of Agricultural and Biological Engineering, University of Florida, USA, [3] Centre Regional Aghrymet (CRA), Niger

Abstract: Tillering is a complex process which depends upon several factors that interact together. In West Africa, sorghum usually grows in conditions characterized by a short rainy season with dry spells, a high potential evapotranspiration rate, low soil fertility, and a low level of adoption of suitable farming technologies. In those conditions, planting in low density is a strategy to insure a minimum yield. Thus, understanding the main factors that affect tillering production under limiting conditions of growth and development of sorghum could help obtaining better management strategies for a sustainable production. The objective of this study was to determine the effect of photoperiod on tillering behavior of sorghum varieties in Burkina Faso, West Africa. A planting date study using 11 local sorghum varieties was conducted from June to August of 2003, 2004, 2006 and 2007 at the experiment station of Di in northwestern Burkina Faso. The number of stems at harvest time, the number of stems with panicle, the maximum number of stems hill-1, thermal time from emergence to maximum number stems hill-1 and photoperiod at maximum number of stems hill-1 were used to discuss and to characterize the dynamic of tillering. Our results show that the maximum number of tillers and the thermal time from emergence to reach maximum number of tillers were both affected by photoperiod or planting dates. The longest photoperiod, warm temperature, and the onset of organic matter mineralization at the beginning of the rain season were conditions that stimulated tillering. Further work will include the use of these results to improve crop management in West Africa.

Keywords: Sorghum bicolor (L) Moench, tillering, photoperiod, planting date, Burkina Faso, West Africa.

Session 2.5 Crop Model Improvement and Genetics Applications

40. *Poster Presentation*

Title: **Model improvements for simulating heat stress in irrigated wheat by considering canopy temperature in a semi-arid environment: a multi-model comparison**

Authors: Heidi Webber[1], P. Martre[2], S. Asseng[3], B. Kimball[4], J. White[4], M. Ottman[5], G. W. Wall[4], G. De Sanctis[6], J. Doltra[7], R. Grant[8], B. Kassie[3], A. Maiorano[2], J. E. Olesen[9], D. Ripoche[10], E. E. Rezaei[1], M. A. Semenov[11], P. Stratonovitch[11], and F. Ewert[1]
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Abstract: To account for the more frequent occurrence of extreme high temperatures expected under climate change, many models have focused on simulation of heat stress effects. However, most attempts to model heat stress have used air temperature (Tair), rather than crop canopy temperature (Tc). Recent improvements in models include the simulation of canopy temperature and range from empirical (EMP) to complex iterative models solving an energy balance correcting for atmospheric stability conditions (EBSC). A greatly simplified variation of the energy balance models assumes neutral stability conditions (EBN), avoiding iteration. The objectives of this study are: (1) to compare these new EMP, EBN, and EBSC approaches to simulate Tc and grain yield, and (2) to assess if simulation of Tc improves the ability of crop models to capture heat stress impacts. Nine crop models (three of each type) simulated crop growth and development for irrigated spring wheat in Arizona for a series of planting dates. The simulations were conducted twice: (1) using Tc on processes sensitive to heat stress and (2) using Tair on processes sensitive to heat stress. The three EBSC models had the lowest RMSE (2.9°C) while the three EBN had the highest (6.7°C). The RMSE of the EMP models was 3.9°C. Despite their relatively poor simulation of Tc, the EBN models simulated grain yields with lower RMSE (1.7 t ha-1) than the others. The use of Tc versus Tair lead to some improvements in simulating grain yield for most models.

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57. *Poster Presentation*

Title: **Daphne: a generic database to integrate multiscale agronomic and phenotypic information for crop modelling**

Authors: Lauriane Rouan[1], D. Pot[1], M. Boulnemour[1,2], and S. Auzoux[2]
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Abstract: Studies of genotype x environment x management (GXEXM) interactions commonly use Crop Simulation Models (CSM). The minimum datasets required for a successful model implementation are multi-scale, multi-species and multi-disciplinary. We observed that although they are organized differently, CSM input files and field experiment datasets shared the same measurements (yield, leaf area index, biomass, etc.) and a few similar tables corresponding to the minimum dataset (weather, soil, crop, and management data). Based on this analysis, we have designed the schema of DAPHNE.

We used the relevant technology of metadata. Thus, in DAPHNE, all variable labels are stored in a metadata table including the units and methods of measurements and the observed and experimental units. The main advantage of this technology is that the addition of any variable does not imply to reconsider the structure of the database. Database query performance is also improved. DAPHNE already has a wide application in GXEXM experiments on sorghum and sugarcane. The genericness of the schema of DAPHNE can allow intercomparison of CSM that require the same datasets with no common data structure.

Session 2.6 Global Economics and Integrated Assessments

Oral Presentation

Title: **From SSPs to global RAPs – a conceptual framework**

Authors: Hermann Lotze-Campen[1], D. van der Mensbrugghe[2], H. van Meijl[3], I. Perez-Dominguez[4], K. Wiebe[5], A. Popp[1], F. Humpenoeder[1], B. Bodirsky[1], A. Biewald[1], S. Fujimori[6], T. Hasegawa[6], E. Stehfest[7], T. Kra[7], A. Tabeau[3], P. Havlík[8], H. Valin[8], K. Kavallari[9], P. Kyle[10], T. Brunelle[11], R. Sands[12], M. Springmann[13], and B. O'Neill
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Abstract: We present a conceptual framework for developing a set of global Representative Agricultural Pathways (RAPs), which can be used for foresight exercises to assess long-term trends in global agriculture, especially under conditions of climate change and/or ambitious greenhouse gas mitigation efforts. The RAPs should describe a limited number of future agricultural (agro-economic) trajectories, defining a set of key inputs and outputs for model-based analyses of global food demand, agricultural production, food prices, trade, and land use change. The work builds on previous efforts by Valdivia et al. (2015) and O'Neill et al. (2015). The RAPs will be based on the narratives and implementation of Shared Socioeconomic Pathways (SSPs) (O'Neill et al. 2015). The SSP narratives already contain quantitative information on GDP and population as well as important qualitative descriptions on key characteristics relevant to future global agriculture: productivity growth, globalization and trade liberalization, environmental and land use change regulations, lifestyles and dietary preferences. The RAPs add to these, as far as necessary, more specific agricultural elements, e.g. changes in domestic and regional agricultural policies. The SSP/RAP elements will be used to harmonize model assumptions and key inputs among 10-15 global economic models participating in AgMIP and partly in the Inter-Sectoral Impact Model Intercomparison Project (ISI-MIP). All quantitative elements of the RAPs may also be described in an agricultural narrative that would allow for quantification of other elements needed by other modeling groups, such as the global gridded crop models (GGCMs) or regional economic models.

Oral Presentation

Title: **Climate change stabilization and the global agricultural sector under alternative future development scenarios**

Authors: Petr Havlik[1], K. Calvin[2], S. Fujimori[3], A. Popp[4], E. Stehfest[5], H. Valin[1], B. Bodirsky[4], O. Fricko[1], F Humpenöder[4], H. Lotze-Campen[4], and M. Obersteiner[1]
[1] IIASA, Austria, [2] PNNL, USA, [3] NIES, Japan, [4] PIK, Germany, [5] PBL, The Netherlands

Abstract: Agriculture, forestry, and other land use(AFOLU) is, with 25%, the largest contributor to global anthropogenic GHG emissions. This alone would suffice to make the ambition of the Paris COP21 Agreement to stabilize global temperature rise below 2 degrees a formidable challenge for the sector. In addition, this target, will require large amount of negative emissions. But the two major sources of negative emissions - afforestation and bioenergy with carbon capture and storage (BECCS)- require large amounts of land and hence enter directly in competition with the traditional agricultural production. Shared Socio-economic Pathways (SSPs) together with the Representative Concentration Pathways (RCPs) represent the backbone of the new IPCC scenario framework. The five SSPs have been designed to spread the space of plausible future developments. Agricultural sector is treated in detail, with particular attention to technological change, dietary preferences, losses and wastes along the supply chain, and international trade. Five integrated assessment modeling teams, all of them participating in the Global Economic Group of AgMIP, transposed the SSPs narratives into quantitative model drivers and quantified the scenarios. Here, we provide the most important results in terms of agricultural markets developments as well as resource use. After a brief summary of the different agricultural sector futures in the reference scenarios, we focus on the expected contribution from the agricultural sector to climate change stabilization at around 2 degrees, and discuss what the major agricultural and land use mitigation strategies in the different models are and what their relative contribution to the target is.

Session 2.6 Global Economics and Integrated Assessments

Oral Presentation

Title: **Dynamic economic model of arable crop rotation**

Authors: Ian McFarlane
University of Reading, UK

Abstract: Rapid progress is being made in CRISPR and other forms of gene editing technology. The techniques are helping to reduce the cost of development of arable crops with traits to alleviate biotic and abiotic stresses, and to provide nutritional and other downstream benefits. The investment required to develop and obtain approval for new traits to be released into the environment remains substantial. An economic model has been developed to provide a decision support tool for assessing the return on investment in crops with novel traits, as part of a work package with the FP7 project 'Assessing and Monitoring the Impacts of Genetically modified plants on Agro-ecosystems' (AMIGA) (www.amigaproject.eu). The progress of a novel crop compared with an equivalent conventional crop is modelled in monthly time steps, with management decisions about application of controls (pesticide or herbicide for example) applied at each monthly step. The simulation extends over up to seven crop cycles, enabling simulation of the effect of crop rotation on soil condition, including decisions regarding use of tillage. In this paper, we report simulation of arable farm gross margin over typical crop rotations before and after inclusion of crops with novel traits as one or more of the crops in the rotation. The results include simulation of variation in crop stresses that may arise as a consequence of climate change.

Oral Presentation

Title: **Intensification and production reallocation: Attributing land-use changes to their underlying drivers**

Authors: Thierry Brunelle[1], P. Dumas[1], and W. B. Aoun[2]
[1] CIRAD, UMR CIRED, France, [2] INRA, UMR ECOSYS, France

Abstract: Debates on bioenergy production emphasized the complex nature of land-use changes which put into play responses from the demand and supply-side based on price signals and biophysical potentials. Every change in agricultural production leads to mechanisms of intensification, production reallocation and changes in demand which usually refer to as indirect land-use changes (ILUC). These indirect effects have been estimated by many studies, however their mechanic has never been made completely explicit. Thus, to improve our understanding of land-use dynamic, the objective of this paper is to attribute as precisely as possible land-use changes to their underlying drivers. The following processes are considered: changes in yield due to (i) input use and to (ii) expansion on marginal lands, and changes of production allocation (iii) across countries and (iv) across sectors (between crop and livestock). This study provides first an analytic decomposition of land-use changes from a production shock that makes it possible to distinguish between land-use changes directly resulting from the production shock and those resulting from price-induced effects. A numerical analysis is then conducted using the global model of land-use NLU in the case of a biofuel scenario from rapeseed in France.

Session 2.6 Global Economics and Integrated Assessments

Oral Presentation

Title: **Alternative Futures for Global Food and Agriculture**

Authors: Martin von Lampe
OECD

Abstract: The OECD study Alternative Futures for Global Food and Agriculture provides insights into possible futures, challenges and opportunities facing the agricultural systems. Three alternative scenarios depict alternative pathways which the world may follow towards 2050. They were developed and analysed by officials of agricultural ministries in OECD and emerging economies. Where possible, the scenarios were quantified with the help of four global economic models. More qualitative scenario elements were analysed by various subject experts. This paper focuses on the interaction between ministry officials, economic models and subject experts, coordinated and facilitated by the OECD Secretariat. The involvement of agricultural Ministries throughout the project was pivotal for raising the relevance of the study outcomes for public policies, both in terms of substance and buy-in. Officials therefore were defining the fundamentals of the three scenarios as well as prioritising the focus areas of the analysis, before discussing outcomes and policy messages. At the same time, given the breadth of the analysis, the expertise of academics and industry analysts was important to provide the required basis for debates on specific challenges and policy options. Finally, with the quantification of both the scenarios and of several choice strategies, four of the AgMIP Global Economic Models provided numerical information on significant scenario elements. The combination of policy involvement, substance expertise and quantitative modelling generated strong global recommendations. To make them more operational, the scenarios and conclusions are open for discussion at regional, national and sub-national levels to challenge and refine assumptions, outcomes and conclusions.

Oral Presentation

Title: **A simple recursive dynamic long-term agricultural sector model**

Authors: Marcel Adenauer
OECD, Trade and Agriculture Directorate

Abstract: Economic agricultural sector models have been used widely to analyse not only medium term impacts of changes in the economic and political environment but also to address long term questions regarding resource constraints and climate change. Many of those models are quite detailed in terms of spatial representation of agricultural supply, commodity disaggregation or trade representation. A study which was taken out at the OECD where long term future scenarios were assessed with several of these models found that prices for agricultural commodities would increase considerably compared to the last decade in almost all scenarios that were analysed. At the same time OECDs medium term projections suggest that prices are not going to increase much in the coming 10 years. To attain a better understanding on how medium term projections of agricultural markets link into their long term prospects, a simplified model for agricultural commodity markets was developed in the spirit of Tom Hertel's SIMPLE model. This partial equilibrium model which will be presented here operates on a highly aggregated regional and product scale with only a few parameters steering model response and it has the potential to enhance the toolbox of existing models being capable to quickly assess how basic drivers like population, economic and productivity growth are interlinked with future supply, demand and price levels of food commodities.

Session 2.6 Global Economics and Integrated Assessments

41. *Poster Presentation*

Title: **Towards a new generation of Decision Support Models: The TOA-MD Model version 6.1 and Tools for Impact Assessment**

Authors: John Antle[1] and R. Valdivia[1]
[1] Oregon State University, USA

Abstract: The TOA-MD model is a parsimonious, generic model for analysis of technology adoption, climate impact assessment and ecosystem services analysis. The TOA-MD model simulates technology adoption and impact in a population of heterogeneous farms. There are several features of this model that are novel as compared to most other economic models being used for technology adoption and climate impact assessment. The TOA-MD represents the whole farm production system (i.e. includes crops, livestock and aquaculture sub-systems, and the farm household characteristics). The TOA-MD is a model of a farm population, not a model of an individual or "representative" farm. Accordingly, the fundamental parameters of the model are population statistics – means, variances and correlations of the economic variables in the models and the associated outcome variables of interest. With suitable bio-physical and economic data, these statistical parameters can be estimated for current systems. Using the methods such as the AgMIP Regional Integrated Assessment approach, we can estimate how the TOA-MD model parameters would change in response to climate change or technological adaptations. These changes in model parameters are the basis for the climate impact, vulnerability and adaptation analysis. The TOA-MD simulates impacts that are statistically associated with adoption, using the standard statistical framework for econometric policy evaluation in which economic "agents" – in our context, farms – self-select into "treatment", i.e, choose to adopt or not adopt. The model can be used to estimate the so-called "treatment effects" or the impacts associated with technology adoption. The impacts of climate change estimated by the TOA-MD model are the "treatment effects" of climate change. In this presentation we also describe several tools developed to design Representative Agricultural Pathways (RAPs) and to estimate TOA-MD model parameters. These tools are used to facilitate the implementation

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42. *Poster Presentation*

Title: **Crop Yields, Food Security, and GHG Emissions: An Analysis of Global Mitigation Options for Rice Cultivation**

Authors: Robert Beach[1], J. Creason[2], Z. Hussein[2], S. Ragnauth[2], S.B. Ohrel[2], C Li[3], and W. Salas[4]
[1] RTI International, [2] EPA, [3] University of New Hampshire and Applied Geosolutions, [4] Applied Geosolutions

Abstract: Global agriculture faces the dual challenges of improving food security for a growing population while simultaneously reducing the environmental footprint of agricultural production, including net greenhouse gas (GHG) emissions. Paddy rice production is the 5th largest source of methane emissions, globally. However, the impacts of crop production decisions extend beyond the overall economic costs and benefits. Fueled by concerns over ethanol, a lively debate has emerged over food security issues (Searchinger, et al 2013) and other distributional concerns. Rice is a staple crop produced in areas with fast-growing populations that have been plagued by food shortages. While mitigation of methane from rice cultivation may be relatively low-cost, it might have an adverse impact on food security. Extending prior work on GHG mitigation to examine food security implications, we used the GTAP model is to examine domestic consumption and trade flows between 140 countries in the v9 GTAP data set. Food security is assessed using food balance sheet data from the FAO. We find that at carbon prices up to $50 the result on food security is mixed. This analysis provides valuable insights into the potential tradeoffs and synergies between food security and GHG mitigation from rice cultivation in different parts of the world.

Session 2.6 Global Economics and Integrated Assessments

43. *Poster Presentation*

Title: **Implications of climate change for agricultural GHG mitigation in Latin America**

Authors: Robert Beach[1] and S. Waldhoff[2]
[1] RTI International, [2] PNNL

Abstract: Climate change is expected to have impacts on agricultural productivity that will vary substantially both spatially and temporally. Among other effects, these productivity shocks are likely to alter the relative attractiveness of alternative strategies for greenhouse gas mitigation. These interactions make it very important to consider potential future climate when estimating mitigation potential. However, there have been relatively few studies that have explicitly examined interactions between productivity impacts induced by climate change and mitigation potential from the agricultural sector. In this study, we examine the implications of alternative climate scenarios for mitigation potential as well as for the mix of mitigation options that would be used. Although the primary focus is on Latin America, we reflect global scenarios in order to capture interactions between agricultural markets through international trade. We apply the Applied Dynamic Analysis of the Global Economy (ADAGE) computable general equilibrium model to examine scenarios both independently as well as in combination and calculate the marginal impacts of incorporating climate change impacts into mitigation analyses based on the differences between scenarios. We find important differences in the optimal mitigation portfolio and distribution of mitigation activities across global regions across climate scenarios. Our findings suggest that individual countries should take into consideration the overall costs and benefits associated with adaptation and mitigation policies as well as the interactions of domestic policy with international policies when designing programs and policies.

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44. *Poster Presentation*

Title: **Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS): A National Science Foundation (USA) initiative to examine critical issues in today's world**

Authors: James W. Jones[1], J. Lighty[2], B. Schottel[3], and A. Zycherman[4]
[1] INFEWS Program Director, [2] Division Director, [3] Science Analyst for INFEWS, [4] AAAS Science and Technology Policy Fellow, National Science Foundation, Directorate for Engineering, Division of Chemical, Bioengineering, Chemical and Environmental Systems (CBET), USA

Abstract: At the end of 2015, the National Science Foundation (NSF) put out its first request for proposals for the INFEWS program (Innovations at the Nexus of Food, Energy, and Water Systems). The program, funded at 35 Million Dollars for the 2016 fiscal year, and consecutively (expected) over the next five years, will fund interdisciplinary projects that fall into four tracks 1. System modeling, 2. Visualization and Decision Support, 3. Innovative System Solutions, and 4. Education and Workforce Development. The program expects to tackle Food-Energy-Water System (FEWS) research through integration across disciplines, in which agricultural and food systems research is a primary component. To this end NSF has partnered with the United States Department of Agriculture (USDA) to fund related research. This program developed from the Science, Engineering and education for Sustainability (SEES) program, which in 2015 funded 17 FEWS workshops. These interdisciplinary workshops brought together researchers and other stakeholders from universities, local, state, and federal governments, industry, and non-profits to examine a wide range of FEW questions and identify the research, data and technological needs to solve them. This poster presents an overview of the development of the INFEWS program, some pressing FEW needs as identified by the broader research community, and national and international opportunities for future engagement with the program.

Session 2.6 Global Economics and Integrated Assessments

45. *Poster Presentation*

Title: **Sustainably intensifying global cropland by considering yield-environmental tradeoffs**

Authors: Wenfeng Liu[1] and H. Yang[2]
[1] Eawag, Swiss Federal Institute of Aquatic Science and Technology, Switzerland, [2] Eawag, Swiss Federal Institute of Aquatic Science and Technology; Faculty of Sciences, University of Basel, Switzerland

Abstract: In the context of global population growth, diet shift to more calorie- and protein-consumption, and biofuel competition, agriculture is facing the triple challenges a) meeting the global increasing food demand, b) alleviating the environmental impacts, and c) minimizing the additional inputs. Due to constraints of cropland expansion and its highly environmental costs, sustainably intensifying the existing cropland is key to address these challenges. Here, the Python-based Environmental Policy Integrated Climate (PEPIC) model is used to investigate the tradeoffs between crop yield improvements and environmental costs by considering different intensification scenarios. This study focuses on three major cereal crops: maize, rice, and wheat. Results show that some regions have high potential to increase yields especially in Africa and South America by increasing nitrogen and irrigation inputs, while the potential is already exhausted in many other places. The marginal returns of nitrogen fertilizer and irrigation and environmental costs present different spatial patterns. High environmental costs are associated with low marginal returns of nitrogen fertilizer. By intensifying agriculture in regions with low environmental costs, global average yield improvement would be only slightly lower than the scenario of intensification over the whole cropland, but nitrogen losses and the additional demand for nitrogen and irrigation inputs under the former are much smaller than the latter. This study suggests the importance of considering yield-environmental tradeoffs in sustainable agricultural intensification and highlights the regions with high potentials of doing so.

Session 2.7 Regional Integrated Assessments

Oral Presentation

Title: **Climate Change Impact on the productivity of crops in smallholder systems in West Africa: The case of Navrongo, Ghana and Nioro, Senegal**

Authors: D. S. MacCarthy[1], B. S. Freduah[1], S.G.K. Adiku[1], M. Ly[2], S.B. Traore[2], S. Narh[1], and P.S. Traore[3]
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Abstract: Climate change is evident in Ghana with increasing temperatures and reducing annual seasonal rainfall amount which has become more erratic in almost all the agro-ecological zones. Farmers in Ghana are expected to be adversely affected by these changes in climate due to their reliance on rain-fed agriculture. Using two crop simulation models; Agricultural Production Systems Simulator (APSIM) and Decision Support Systems for Agro-Technological Transfer (DSSAT) these AgMIP tools were used to simulate cereal (maize and sorghum/millet) and groundnut yields for Navrongo, Ghana and Nioro, Senegal under current climate (1980 – 2009) and thereafter for 5 future climates (Mid Century time slice 2040 – 2069) under RCPs 4.5 and 8.5. Farmer survey data was used as input data on crop management practices and complemented with data from relevant literature to successfully initialize the two models and to represent observed yields from the survey. Generally, the 2 crop models agreed on the direction of change in yield. Uncertainty, however, remains in the magnitude of change as the models did not agree in this regard. Projected yield changes varied among GCMs and RCPs. Similarly, the magnitude of impact differed between the 2 locations with climate change impact being more severe in Nioro than in Navrongo. Methodologies employed in model initialization as well as the probable reasons for the differences in magnitude of model predictions will be discussed. The output of the models have been used to assess the impact of Climate change on the livelihoods of farmers in the two locations.

Oral Presentation

Title: **Reducing vulnerability to climate change in semi-arid Zimbabwe: a multi-model approach for redesigning smallholder farming futures**

Authors: Sabine Homann-Kee Tui[1], K. Descheemaeker[2], P. Masikati[3], G. Sisito[4], R. Valdivia[5], O. Crespo[6], B. Francis[7], L. Claessens[1]..
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Abstract: Climate change will impact productivity and food security of maize-based crop-livestock systems in semi-arid Zimbabwe. Earlier results from testing climate change adaptation options in Nkayi district showed that incremental technology-based changes are insufficient for improving smallholder livelihoods affected by climate change. In this paper we therefore explored requirements and potential impacts of transformative systems redesign. Scientists and stakeholders engaged in new thinking on drivers and opportunities for supporting desirable change, assuming that improved access to inputs, knowledge and markets would encourage smallholders adopting improved practices and technologies. Significant improvements in productivity, food security and income was achieved through a combination of larger cultivated areas, more diverse food and forage crops, integrated soil fertility management, small-scale mechanization, integrated with more livestock and improved livestock management. Food security oriented adaptation packages focusing on small ruminants and expanding groundnut and sorghum production would provide 76% increases in net returns for extremely poor farms. Market-oriented livestock production with improved fodder and manure management would increase the net returns of poor and non-poor farms up to 85%. More than a third would however persistent below minimum living standards, indicating the need for opportunities outside agriculture. Translating innovations into multi-modeling frameworks enabled comparison of purely climate and socio-economic effects and informed adaptation strategies at farm and larger scales. This approach supports policy decisions, illustrating that future socio-economic conditions and policies are key factors for reducing vulnerability and create sustainable futures for areas like semi-arid Zimbabwe.

Session 2.7 Regional Integrated Assessments

Oral Presentation

Title: **Impact of climate change on irrigated maize in Tamil Nadu, Southern India**

Authors: Geethalakshmi Vellingiri, R. A. Palanisamy, B. Kulanthaivel, G. Ramasamy, S.P. McDermid, M. Narayanasamy, L. Arunachalam, S. Kandasamy, V. Krishnaraj, A. Krishnamoorthi, K. Sembanan, P. Shanmugam. Agro Climate Research Centre, Tamil Nadu Agricultural University, India

Abstract: Climate change is one of the most pressing global problems; the impacts are felt by the human society on regional to local scales. Here, we quantify the impact of climate change on maize in the Trichy district in Tamil Nadu, India through integrated climate-crop assessment utilizing the Protocols developed under Agricultural Model Inter-comparison and Improvement Project (AgMIP). Baseline climate data (1980-2010) was obtained from the TNAU agro-meteorological observatory. Future climate projections were taken from five global climate models obtained from the Coupled Model Inter-comparison Project (CMIP5) database, which were selected to represent the spread of uncertainty in climate projections from the full GCM ensemble. To simulate crop yields over both historical and future climate time scales, we utilized the Decision Support System of Agrotechnology Transfer (DSSAT) and the Agricultural Production Systems Simulator (APSIM) crop system models. Both DSSAT and APSIM model simulations under RCP 8.5 climate conditions (without adaptation) predicted decreased maize yields, with varied magnitude, for all the five models. Forcing CanESM2 (Hot-Wet condition compared to other models), inmcm4 (Hot-dry), IPSL-CM5A-MR (Cool-wet), MIROC 5 (Cool-dry) and HadGEM2 (Middle condition) models with APSIM showed a deviation in maize productivity by (-)8 to (+5), (-)3 to (+)7, (-) 2 to (-)8, (-)4 to (+)14.6 and (-)6 to (+)9 per cent respectively. While with DSSAT forcing, CanESM2, inmcm4, IPSL-CM5A-MR, MIROC 5 and HadGEM2 models showed (-)11 to (-)22, (-)2 to (-)7 , (-)10 to (-)33, (-)2 to (-)7 and (-)8 to (-)19 per cent deviation in maize productivity compared to baseline yield.

Session 2.7 Regional Integrated Assessments

Oral Presentation

Title: **Assessment of Climate sensitivity to present production system and evaluation of use of adaptation strategies to improve the livelihood security of small and marginal farmers of Indo-Gangetic Plains of India – A multi-crop-climate-economic modeling approach**

Authors: Nataraja Subash[1], H. Singh[1], A.S. Panwar[1], M. S. Meena[2], S. V. Singh[3], B. Singh[4], G. P. Paudel[5], G. Baigorria[6], A. C. Ruane[7], S. P. McDermid[8], K. Boote[9], P. Paulton[10], C. Porter[9], R. O. Valdivia[11], C. Rosenzweig[7], J. W. Jones[9], J. M. Antle[11], and C. Mutter[12]
[1] ICAR-IIFSR, [2] ICAR-ATARI, [3] ICAR-NDRI, [4] CIMMYT, [5] TNAU, India, [6] University of Nebraska-Lincoln, USA, [7] NASA Goddard Institute for Space Studies, USA, [8] New York University, USA, [9] University of Florida, USA, [10] CSIRO, Australia, [11] Oregon State University, USA, [12] Columbia University, USA

Abstract: Indo-Gangetic Plains, the food basket of India experienced climatic variability/fluctuations, occurrence of extreme events during last 30-years at one or other places and affected the current production system and thereby food and nutritional security and livelihoods of small and marginal farmers, which contributes 80 % of the farming population. Even though the green revolution brought irrigation/infrastructural development in this region, the spatial and temporal variability of monsoon, occurrence of cold waves, heat waves, unusual occurrence of rainfall during different pheno phase of the crop determines the final productivity. Under Agricultural Modeling intercomparison and Improvement Project, we have studied the climate sensitivity to present production system and also evaluated the adaptation strategies to improve the productivity in Indo-Gangetic plains of India. The AgMIP Phase II protocols were used to study the linking of climate-crop-economic models for two study sites Meerut and Karnal. At Meerut, the decadal trends in meteorological parameters showed significant decreasing trend of June rainfall of the order of−50.3 mm/decade; this may affect the level of groundwater. This leads to higher input costs. In the case of wheat, a significant increasing trend of maximum temperature during March and April could be one of the reasons for decreasing wheat grain yields. The increasing trend of maximum temperature during the milking/dough stage may result in forced maturity, which decreases the grain size and thereby grain yield. The adaptation strategies such as use of short duration varieties in rice and wheat, advancement of date of sowing in wheat etc along with conservation measures were identified after discussion with local stakeholders, which increases the productivity and thereby increases the livelihood security of small and marginal farmers of the Indo-Gangetic plains of India.

Oral Presentation

Title: **Evaluating Crop Models for Use with Economic Models in Integrated Assessment**

Authors: John Antle[1], L. Claessens[2], S. Gummadi[3], R. Valdivia[1], H. Zhang[1], C. Dixon[1]
[1] Oregon State University, USA, [2] ICRISAT Kenya, [3] ICRISAT Ethiopia

Abstract: Crop simulation models are used in integrated assessments to quantify the effects of changes in climate and management on crop productivity. They can be used to represent these effects using point data (e.g., matched to spatial coordinates of farm survey data) and with data averaged over a spatial unit and over time (e.g., gridded data). Economists are using crop models as well as observational data to represent the spatial heterogeneity in crop productivity as well as the temporal variation. The crop models may be used to represent changes in absolute or relative productivity. Crop modelers typically evaluate the performance of crop simulation models using several criteria, including probability of exceedance graphs and plots of observed versus actual yields. The AgMIP Regional Integrated Assessment Handbook summarizes these methods and also suggests ways that crop models can use farm survey data in implementation of impact and adaptation analysis. This paper uses examples from recent research to critically evaluate these methods, the types of data that are being used, and the adequacy of these methods and data for carrying out integrated assessments.

Session 2.7 Regional Integrated Assessments

Oral Presentation

Title: **Future Climate Change and Its Effect on Maize Yields in Selected Semi-arid Areas of Southern Africa**

Authors: Weldemichael Tesfuhuney[1], O. Crespo[4], T. Mpuisang[2], M.Teweldemedhin[7], P. Gwimbi[9], W. Durand[3], Y. Beletse[3], M. Jones[6], S. Walker[1,4], and D. Cammarano[5]
[1] University of the Free State, South Africa, [2] Botswana College of Agriculture, Botswana, [3] Agricultural Research Council, South Africa, [4] University of Cape Town, South Africa, [7] Polytechnic of Namibia, [5] National University of Lesotho, Lesotho, [5] The James Hutton Research Institute, Scotland, [4] University of Nottingham, UK

Abstract: Climate change impact projections in countries of Southern Africa (SADC) reveal increased occurrences and severity of drought. AgMIP creates a robust framework to understand the climate impact on main stable crops. The aim of the study was to assess and compare historical and future maize (Zea mays L.) yield simulations using APSIM with historical (1980-2010) and mid-century future (2040-2070) climate scenarios on 12 selected semi-arid areas of SADC. Tools and protocols developed for crop modelling in AgMIP were adopted to address improved projections of climate impacts on smallholder maize production with and without adaptation.
Summary results of yield simulations
Countries in SADC Sites No. of
Farmers Performance Historic
(t ha-1) Mean Future Scenarios (t ha-1) with Adaptation
R2 RMSE CCSM GFDL HADG MICR MPI Mean
South Africa 3 2254 0.53 624 1.44 1.63 1.54 1.75 1.63 1.35 1.58
Botswana 1 30 0.59 355 0.49 0.75 0.74 0.80 0.92 0.35 0.71
Namibia 6 467 0.46 639 0.27 0.39 0.42 0.49 0.52 0.62 0.49
Lesotho 2 30 0.65 548 0.66 1.04 0.84 0.70 0.69 0.80 0.81
Model performance showed reasonable values, when only district yields were used for testing, in spite of climate related year-to-year variations. Future climate change shows variability in yields, that makes maize production more risky without improved adaptations. Diversified potential management practices due to climate change would improve rural livelihoods. Thus, current maize production system is sensitive to climate change, giving a negative impact of climate change on future maize production in the semi-arid areas of SADC region.

46. *Poster Presentation*

Title: **The Regional Gridded Crop Modelling Activity (RGCMA) - India Focus**

Authors: Delphine Deryng[1], C. Deva[2], J. Elliott[1]
[1] University of Chicago & NASA GISS, USA, [2] University of Leeds, UK

Abstract: We present the first of a new set of regional activities designed to apply gridded crop modelling methods over large areas using high resolution climate and agricultural inputs to improve and harmonise impact, adaptation and vulnerability (IAV) assessments across regions. Agriculture in India undergoes dramatic groundwater resources depletion. Projected climate change is expected to impact both water resources for irrigation and crop yield. This Regional Gridded Crop Modelling Activity (RGCMA) activity aims to explore the interaction between irrigated crop production and ground water resources in India under climate change using an ensemble of gridded crop models and high resolution regional climate and agricultural datasets. The overall motivation, objectives and methods will be presented; interaction with and complementarity to other regional and global AgMIP activities will be discussed.

Session 2.7 Regional Integrated Assessments

47. *Poster Presentation*

Title: **Assessing climate impacts to critical indicators of farmers' livelihood: a carbon, temperature, and water sensitivity analysis**

Authors: Sonali McDermid[1], R. Valdivia[2], A. C. Ruane[3], J. Antle[2], and D. Murthy[4]
[1] New York University, USA, [2] Oregon State University, USA, [3] NASA GISS, USA, [4] ICRISAT, India

Abstract: The AgMIP Coordinated Climate-Crop Modeling Project (C3MP) engages the global crop modeling community to explore crop and model sensitivities to changes in carbon dioxide concentrations ([CO_2]), temperature (T), and precipitation (W) utilizing a standardized set of experiments and analysis protocols. Modelers run their calibrated crop models over a 30-year period, modifying their weather data to include a range of CTW changes from 99 prescribed sensitivity tests. A series of Impacts Response Surfaces (IRS) are created from the resulting yield changes to explore the modeled sensitivity to the CTW uncertainty space. These IRS allow researchers to expediently estimate CTW impacts, such as those associated with increasing [CO_2] and T while holding W constant (a proxy for climate change conditions).

While C3MP methods have been primarily used to evaluate crop sensitivities to CTW changes, we now expand this approach to evaluate these impacts on key economic indicators: poverty rates, vulnerability, and farm income. This assessment is conducted for 90 rainfed maize farmers in Andhra Pradhesh, India, and each farm has been modeled for 30 years with their respective management conditions. For each farm, the relative yield changes from the baseline are computed for each sensitivity test, and serve as one farm system input in the TOA-MD modeling framework. For each of the specified economic indicators, the mean response to each sensitivity test is assessed across the population of farms. From this mean response, IRS are constructed to analyze the indicators' sensitivity to CTW changes, and identify critical thresholds of farm livelihood impacts.

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48. *Poster Presentation*

Title: **Spatial analysis of profitability of Chickpea farms under changing climate in Andhra Pradesh, India**

Authors: Swamikannu Nedumaran[1], K. D. Murthy[1], D. K. Charyulu[1], and M. K. Gumma
[1] ICRISAT, India

Abstract: Chickpea (Cicer arietinum L.) is the largest pulse crop grown in India and the second largest food legume in the world. In India, the growth rate of chickpea area is highest in Andhra Pradesh state followed by Karnataka, Maharashtra and Madhya Pradesh between 1970 and 2010. In the last two decades, chickpea become a major pulse crop grown under rainfed condition in semi-arid tropics of Andhra Pradesh. The fallow-chickpea cropping systems covers more than 70% of the cropped area which replaced crops such as sorghum, sunflower, coriander and groundnut mainly because of higher returns of chickpea. But in the recent years, Andhra Pradesh semi-arid region is facing frequent drought and erratic distribution of rainfall which leads to crop failure and loss to the chickpea farmers. The objective of this paper is to assess the spatial variation and sensitivity of gross margins of chickpea farms under changing climate scenarios and also evaluate different climate-resilient adaptation options to improve farm profits. The chickpea growing area in the state was delineated using LANDSAT-8 & MODIS 250 m temporal data with spectral matching techniques. The current and future climate data was used to simulate the chickpea yields using the DDSAT crop system model with farm level management input data collected from 810 spatially heterogeneous representative chickpea farmers from 4 districts of Andhra Pradesh. The farm gate chickpea price and plot level cost of production was used to estimate the spatial variation in gross margins of chickpea farms in four main chickpea growing districts of Andhra Pradesh. The results suggested that the gross margins of chickpea farms differ regionally and needs location specific adaptation options to increase the profitability of chickpea farms. These results will be used to identify the hotspot of chickpea cultivation in the region and to design targeted adaptation options for higher impacts.

Session 2.7 Regional Integrated Assessments

49. *Poster Presentation*

Title: **Uncertainty of GCM projections under different Representative Concentration Pathways (RCPs) at different temporal and spatial scales – Reflections from 4 sites in Indo-Gangetic Plains of India**

Authors: Nataraja Subash[1], H. Singh[1], A. C. Ruane[2], S. McDermid[3], and G.A. Baigorria[4]
[1] ICAR-Indian Institute of Farming Systems Research, India, [2] NASA-GISS, USA, [3] New York University, USA, [4] University of Nebraska-Lincoln, USA, *Corresponding author: nsubashpdfsr@gmail.com, n_suby@rediffmail.com

Abstract: The Projected climate change scenarios are one of the important input variables along with well calibrated crop models for simulating productivity and the uncertainty in Climate change projections sometimes create error in food security projections. Even though the understanding and modeling of climate change has advanced significantly in recent decades, however, the daily projections of maximum and minimum temperature and rainfall by some GCMs still provides biased results in Indian Subcontinent, particularly for specific locations. These GCMs projected somewhat accurate and same projections for larger regions. Under AgMIP (Agricultural Modeling Intercomparison and Improvement Project), we have analysed 29 CMIP5 GCMs under RCP4.5 and 8.5 under near-term (2010-2039), mid-term (2040-2069) and end of the century (2070-2099) for 6 sites in Indo-Gangetic Plains of South Asia. The method followed is mean and variability delta scenarios. The complete methodology followed is explained in AgMIP quick guide to climate scenarios. There is lot of uncertainty involved in subset of GCM selection, which will go to the crop modelers and economic modelers for integrated assessment. Some GCMs showed biasness to explain the projected rainfall scenarios, even in annual/monsoon season with more than 200 % change in projected rainfall. The GCMs which projected more than +200 % change in projected rainfall removed from the methodology and compared which GCMs fall under different quadrants. For eg. We have analyzed 29 GCMs for Meerut District during mid-term century (2040-2069) for RCP4.5 and RCP8.5. Out of 29 GCMs, 6 GCMs (CSIRO-MK3-6.0, IPSL-CM5A-MR, FGOALS-g2, IPSL-CM5B-LR, GISS-E2-R & GISS-E2-H) found biased which projected >200 % annual rainfall. The scatter plotter diagram of 23 GCMs used to identify the GCMs under hot/wet, cool/wet, cool/dry, hot/dry and median quadrants. The GCMs close to mean value were chosen for further analysis.

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50. *Poster Presentation*

Title: **AgMIP-Peru: An Initiative to Assess Climate Change Impacts on Agricultural Systems in Andean Ecosystems: Peruvian Andes as Pilot Site.**

Authors: Irene Trebejo[1] and R. Valdivia[2]
[1] SENAMHI, Peru, [2] Oregon State University, USA

Abstract: Experts from public and private institutions in Peru have formed a multi-disciplinary team under the coordination of the National Meteorological and Hydrological Service (SENAMHI) to assess the impacts of climate change on agricultural production systems in the Peruvian Andes. The pilot site is the region of Puno, situated at above 3,800 meters above sea level, is one of the most vulnerable regions in Peru. Changing climate and climate variability may worsen the already high levels of rural poverty and food insecurity.

The goal is to use the AgMIP Regional Integrated Assessment methods and tools as a proof of concept to build capacity and demosntrate stakeholders and policy makers about the kinds of information this type of assessments can provide.

While the production systems in the Andes are complex crop-livestock systems, this "Fast-Track" analysis will focus on potato based systems. Potato is one of the main stapples in this region and it is also one of the most vulnerable crops to changes in temperature (e.g. frost) and precipitation as well as pest and diseases. This poster will present all the background information about the pilot site and it will also serve as a report of all the previous activities carried out by AgMIP-Peru.

AgMIP-Peru in coordination with AgMIP has conducted 3 workshops between 2013 and 2015 to introduce the AgMIP framework and tools to scientsts from Peru, Ecuador, Chile and Colombia. AgMIP-Peru is also leading the AgMIP-Latin America coordination.

Session 2.7 Regional Integrated Assessments

51. *Poster Presentation*

Title: **In Search of Sustainable Development: Modeling Semi-Subsistence Crop-Livestock Systems to Solve the Poverty-Productivity-Sustainability Puzzle in Sub-Saharan Africa**

Authors: Roberto Valdivia[1], J. Antle[1], and J. Stoorvogel[2]
[1] Oregon State University, USA, [2] Wageningen University, Netherlands

Abstract: Achieving the goal of sustainable development in African agriculture will require better understanding of the poverty-productivity-sustainability puzzle: why high poverty and resource degradation levels persist in African agriculture, despite decades of policy interventions and development projects. We hypothesize that the answer to this puzzle lies, at least in part, in understanding and appropriately analyzing key features of semi-subsistence crop-livestock systems typical of Sub-Saharan Africa: high degree of bio-physical and economic heterogeneity, complex and diversified production system involving a combination of subsistence and cash crops with livestock. We describe an integrated modeling approach designed to incorporate these features. We illustrate how this approach can be implemented to quantify economic and sustainability indicators for policy tradeoff analysis in the Machakos region, Kenya. The analysis suggests that a successful implementation of the Vision 2030 strategy of the Kenyan Government could lead to a sustainable development pathway and achieve newly proposed Sustainable Development Goals

Session 2.8 Information Technologies and Data

Oral Presentation

Title: **An integrated interdisciplinary modelling system of climate change impacts on agriculture in support of adaptation planning: MOSAICC**

Authors: Hideki Kanamaru and M. Evangelisti
FAO

Abstract: Food and Agriculture Organization of the United Nations has been developing a server-based integrated system of tools and models called MOSAICC to evaluate climate change impacts on the agriculture sectors (crops, water resources, forests, and economy). MOSAICC is designed to respond to the needs of developing countries which may benefit from institutional and individual capacity development in producing relevant information for national climate change adaptation planning. This innovative system design facilitates a participatory environment where researchers with different expertise can work together efficiently. The utilization of the Web technologies avoids complex installations on the user's computer and makes maintenance and update of the system on the centralized server simple. MOSAICC is based on open-source technology and models thus it is transferrable to countries free-of-charge. The easy-to-use interface and data sharing/exchange, through central database, support interdisciplinary cooperation among local experts as the chain of simulations and data are transparent to users. Visualization and communication of the results in graphs and maps on the Web are also integral parts of the system. The implementation strategy of MOSAICC in countries emphasizes stakeholder involvement in a technical working group throughout the study in order to produce information that is truly necessary in the country. National experts, who are members of the working group, design the study, perform simulations using MOSAICC, and publish the results to inform stakeholders. In the process, the experts learn the theory, methodology, and the use of models in a series of capacity development workshops.

Oral Presentation

Title: **The Akkerweb platform: models and data to support precision farming**

Authors: Frits K. van Evert[1], T. Been[1], H. N. C. Berghuijs[1], A. J. Haverkort[1], C. Kempenaar[1], G J. T. Kessel[1], E. J. J. Meurs[1], L. P. G. Molendijk[1], A. A. Pronk[1], D. A. van der Schans[1], W. C. A. van Geel[1], and J. A. Booij[1]
[1] Wageningen University, Netherlands

Abstract: It is believed that precision farming (PF) will contribute to increased profitability of farming, to a reduction of the environmental impact of agriculture and, ultimately, to increased global food security. PF is based on the concept of observing and responding to spatial and temporal variability in crops and soils, both between and within fields. Thus, a first challenge in the implementation of PF is collecting and storing large amounts of geo-referenced data; a second challenge is to utilize this data to generate recommendations that can be used by farmers. Akkerweb (http://www.akkerweb.nl) is a web-based portal that allows for safe and easy storage of spatial and temporal soil, crop, climate and management data. Akkerweb provides a mechanism to deliver model-based recommendations, such as variable rate application (VRA) of seeds, fertilizers and crop protection agents. Akkerweb is an initiative of Wageningen UR and the Dutch farmers' cooperative Agrifirm.

We describe first the process of ingesting data from farms, soil analysis labs, unmanned aerial vehicles (UAVs), and satellites, as well as a prototype of automatic data capture. We then detail how modelling is used to generate recommendations to farmers for most of the important decision points in growing potatoes, namely nematode control, application of sidedress nitrogen, late blight control, and potato haulm killing. These recommendations allow potato farmers to reduce the use of nitrogen fertilizer by up to 15% and of crop protection agents by 25% relative to current practice.

Session 2.8 Information Technologies and Data

Oral Presentation

Title: **Enhancing Discoverability and Re-use of CGIAR's Agricultural Data: Challenges and Progress**

Authors: Medha Devare and the Open Access and Data Management Communities of Practice
CGIAR

Abstract: CGIAR's 15 Centers and other entities involved in agricultural research and development are charged with tackling complex challenges at a variety of scales, but research outputs are too often not easily discoverable or reusable. CGIAR is attempting to enhance discovery and reuse of its data for models and other tools through the Open Access and Open Data initiative and the development of a platform to harness the power of big data and ICTs. The OA/OD initiative focuses on creating a culture of data sharing, and provides support for harmonized data through the development of common metadata, ontologies, and strengthened collaboration and coordination around tools and approaches. This foundational work will render CGIAR outputs interoperable, ensuring they are discoverable via integrated and contextualized views across Centers and programs, type (e.g., publications, data, etc.), and discipline (e.g., genetic/genomic; agronomy; breeding; socioeconomic, and other sectors). The contents of most repositories at CGIAR Centers are not generally easily discoverable or inter-linked (e.g., agronomic trial data with socioeconomic or adoption data in the same geography). In the absence of such interoperability-mediated integration, "open" is of limited utility. The overall objective, then, is to make CGIAR's trove of research data and associated information accessible for indexing and interlinking by a robust, demand-driven cyberinfrastructure for agriculture, ensuring that research outputs are Findable, Accessible, Interoperable and Re-usable (FAIR) for simulation, analytics, and visualization tools to enhance innovation and impact. This presentation will review the challenges to sharing and mining CGIAR data effectively, and the progress towards addressing these.

Oral Presentation

Title: **DataMill: a new application to interface researchers' database with crop models**

Authors: Myriam Adam[1], S. Auzoux[2], R. Loison[2], and F. Affholder[2]
[1] CIRAD, UMR AGAP, ICRISAT West Central Africa, Burkina Faso, [2] CIRAD, UR AIDA, France

Abstract: DataMill is an application built to improve access and re-use of agronomic data for crop modelling. DataMill extracts data from a standardized database and then translates these data to compatible model-ready formats for multiple crop models. DataMill is made of: (i) layouts of each input/output file from selected crop models, (ii) a Microsoft Access database (DataMill_DB) that structures all the variables of input/output files, (iii) and a Visual Basic executable file that converts the data from DataMill_DB into model input/output files in native format. The next step is to input researchers' data into DataMill_DB through queries. This step will be crucial and depends on how each researcher is structuring and storing its data.

DataMill facilitates the creation of model input files, one of the major bottlenecks in the use of crop models. Currently, DataMill is working for SARRA-H and DSSAT formats input files and is in development for APSIM and STICS. The concept of DataMill and an example of its use will be presented at the conference.

Session 2.8 Information Technologies and Data

Oral Presentation

Title: **Interlinked data and models using a semantic approach: an example of the RECORD platform in the context of the ANAEE-France project**

Authors: Hélène Raynal, A. Chanzy, C. Pichot , M. El hadramy , E. Casellas, F. Lafolie, and D. Maurice
INRA

Abstract: RECORD is a modelling and software simulation platform dedicated to the study of agro-ecosystems. It is part of the AnaEE-France infrastructure which is a national research infrastructure for the study of continental ecosystems. This infrastructure brings together modelling platforms and databases for long term experiments, and aims at developing interoperability between them. For about two years now, RECORD and the other partners of AnaEE-France have worked together to develop this interoperability using the approach of linked data. In computing, linked data is a method of publishing structured data so that it can be interlinked and become more useful through semantic queries. A thesaurus and an ontology are being developed. The ontology is based on the generic conceptual model proposed by the OBOE ontology. Semantic tools are used. The presentation is intended to illustrate how this approach can be useful in the context of Open Data for Agricultural Modeling. The example of the specific work realized by the RECORD platform will be given. This work aims i) to facilitate the development of simulation applications combining models and experimental data and ii) to help modelers in finding models within the RECORD models library.

Oral Presentation

Title: **Application of AgMIP data interoperability standards to the US National Agricultural Research Data Network for Harmonized Data (NARDN-HD)**

Authors: Cheryl H. Porter[1], J. W. Jones[1], G. Hoogenboom[1], C. Rosenzweig[2], C. Villalobos[1], and M. Zhang[1]
[1] University of Florida, USA, [2] NASA, GISS and Columbia University, USA

Abstract: There is a major gap between the potential value of agricultural research data and current outcomes that are mainly in the form of scientific papers. Vastly greater value could be obtained if datasets were combined across time, locations and management conditions. Most agricultural research data exist in small to medium files on personal computers and hand written notes. The data describe widely diverse systems, hindering development of common databases.
Increasingly, funding agencies are mandating that research data be made available at the end of the project. However, the tools to support researchers in making their data uploadable, findable, accessible, interoperable and re-useable are not available in the agricultural sector. It has, therefore, become clear that a national effort is needed in the US to support researchers complying with federal open data mandates.

The NARDN-HD project proposes to apply the data interoperability standards developed for AgMIP ensemble modeling activities to allow harmonization, archiving, retrieval and aggregation of data from experiments conducted at Agricultural Experiment Stations at US Land Grant Institutions and other USDA-funded projects. This is part of a broader initiative promoting open agricultural data by the USDA National Agricultural Library.

The NARDN-HD system, when implemented, will facilitate advancement of science using data intensive research methods for model development, statistical analyses, and meta-analyses; and will open up opportunities for new scientific discoveries via use of big data analytics spanning multiple sectors. These open data archives will also allow for improved transparency and reproducibility of research findings to funders.

Session 2.8 Information Technologies and Data

52. *Poster Presentation*

Title: **Challenges of integrating expert reasoning in DSS evaluation**

Authors: Romain Bourget[1], A. Bsaibes[1], A. Caffarra[1], G. Garin[1], A. Guaus[1], P. Hublart[1], V. Houlès[1], and P. Stoop[1]
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Abstract: iTK develops software solutions to support the decisions of vine-growers and field technicians. These tools help users optimize their return on investment (RoI) and sustainability for vine irrigation (DSS Vintel®) and pest protection (DSS Bay+ Movida®). They use process-based models that describe the dynamics of soil water content and vine water needs, or disease contaminations and severity.

To evaluate these models, field constraints limit the amount of available data. Classically, these data refer to observations of soil water content (SWC) or disease severity at different dates. In a simplistic approach, direct statistical criteria (e.g. RMSE on SWC or severity) can assess the accuracy of the model on these variables. But the core question remains: "Are the decisions taken with the tool better than without it, in terms of RoI?" Indeed, multiple variables, other than those easily observed can impact decisions. For example, fungicide should be applied when contaminations occur, while only severity is easily observable. Moreover, criteria as RMSE highlight differences on variables at specific observation dates and do not consider dynamical aspects that are crucial in the decision-making process. Finally, user expertise is also ignored by such methods of evaluation.

In this study, we will present examples of how to integrate expert reasoning in model evaluation (i.e. feedback from field technicians). However, because human experts cannot be included in large-scale, automatic routines of parameterization, we will discuss other methods that can be used to formalize and summarize such expertise by statistical criteria: expert-based data weighting, fuzzy logic, Pareto efficiency.

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53. *Poster Presentation*

Title: **Calibration of CropSyst combining available climate information, remote sensing and data and minimum yield data**

Authors: Francisco J. Meza and W. Davila
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Abstract: Crop simulation models (CSM) are a fundamental tool to understand the behavior of complex systems, particularly under uncertain and dynamic climate conditions. One of the most severe limitation for its wide use is the difficulty to achieve a proper calibration due to the extensive date requirements (both in terms of quantity and quality).

The massification of automatic weather stations, that are run following reasonable protocols for quality control and the access of environmental data form satellites has opened new avenues for the development of methods to calibrate CSM and use them as tools to predicts impacts of climate variability and change as well as to carry on ex-ante assessments of adaptation strategies.

Here we present an experiment run using CropSyst that was calibrated with minimum yield data provided by ANASAC seed company and the use of remote sensing data to calibrate phenological changes in Maize.

Results are compared against independent data form the following two seasons showing a reasonably high coefficient of determination (0.85) in terms of biomass accumulation and water consumption.

Session 2.8 Information Technologies and Data

54. *Poster Presentation*

Title: **How to use global sensitivity analysis to improve the user experience of a crop model commercialized in a Web Application? Feedbacks from the conception of CropWin®-Corn**

Authors: Pierre Moreau, K. Bezzou, R. Bourget, A. Guaus, A. Pinet, N. Saint-Geours, and P. Stoop
iTK, France

Abstract: To support farmer in managing nutrient and water inputs for corn and soybean, iTK develops and markets Decision Support Systems (DSS) integrated in Web Applications (CropWin®-Corn, CropWin®-Soybean). These tools aim at helping farmer to improve their profitability by pro-actively managing their cultural practices. The DSS are based on crop models that dynamically simulate, in soils and plants, the processes of carbon, nitrogen, potassium and water cycles on a daily basis to predict crop development and yield gap. The most limiting factors are daily displayed to the farmers. One key challenge of such application development is to limit the number of site-specific and hybrid-specific parameters that are asked to the end-users. This study shows how Global Sensitivity Analysis (GSA) can be an efficient tool to overcome this challenge and to improve user experience.

The aim of GSA is to determine how sensitive the outputs of a crop model are, with respect to the elements of the model which are subject to uncertainty or variability: input variables, equations, parameters. Morris and time-dependent Sobol' methods were used on the corn model on 3 sites under 5 climates and 2 management practices to test the influence of site and hybrid parameters on predicted yields. Involving the end-users throughout the GSA process allowed defining the choice of parameters to be tested and defining the experimental design. We will present in more details how we use GSA to identify the minimum set of parameters asked to the end-users in CropWin®-Corn, and to highlight hybrid-specific information.

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55. *Poster Presentation*

Title: **How weather uncertainty impacts the predicted yield in CropWin-Soybean?**

Authors: Amélie Pinet, R. Bourget, P. Moreau, N. Saint-Geours, and P. Stoop
iTK, France

Abstract: iTK develops and markets software (CropWin®-Corn, CropWin®-Soybean) to support and improve farmer decision making. Our tools are designed so that the farmers can improve their profitability by pro-actively adapting their cultural practices: irrigation and fertilization. Our software are based on crop models that dynamically simulate processes of carbon, nitrogen, potassium and water balance on daily basis to predict crop growth and yield gap.

One key challenge of developing software for farmers is the use of appropriate input data. Indeed, input data accuracy together with an adequate representation of plant physiology processes and choice of model parameters are the key factors for a reliable simulation. One of the most important inputs of our software is the weather: current weather data drive the simulation of the daily growth, while seasonal forecasts are used to predict the yield at the end of the growing season. Some farmers have their own weather stations but most of them do not gather all the required weather data (temperature, rain, solar radiations, relative humidity and wind speed). Thus our models are run using gridded weather data. The uncertainty in weather data is due to both the spatial resolution of gridded data and the use of seasonal forecasts. This uncertainty has a crucial impact on the accuracy and the robustness of our software. In this study, we will present (i) the magnitude of differences between observed, gridded data and seasonal forecast and (ii) the impact of uncertainty in weather data on the yield predicted for three contrasted climates.

Session 2.8 Information Technologies and Data

56. *Poster Presentation*

Title: **CASANDRA: Web based platform to assess impacts and define adaption strategies to climate change.**

Authors: Alfredo L. Rolla[1,2], E. R. Guevara[3], and S. G. Meira[3]
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Abstract: Crop models are used to assess or estimate yield among other important variables such as phenology, dry matter, LAI, soil water content, soil and water management, as well as to evaluate different climate or management scenarios at a particular site. On the other hand, problems involving regional climate change include various spatial scales, and would benefit from simulations over large areas using high-resolution climate data spatially distributed (CMIP5, reanalysis, etc.). The geospatial web platform "CASANDRA" was developed to solve the spatial scale problem combining different site specific crop models (DSSAT, APSIM*, STICS*) with different climate scenarios and typical regional management. This way, it is possible to visualize impacts at both spatial and temporal level and also evaluate different regional adaptation strategies. The platform was design to be easy to use as well as to have the possibility to generate output information to be share with modern devices as smart-phones and tablets, using open source web mapping technologies (OpenLayers) to show results. CASANDRA was design by the concept of "platform independent", "open source" and "cloud development" so it can be use on Windows, Linux, OSX, Android, etc. CASANDRA performs calculations incorporating the concept of homogeneous area, which is simply the intersection of different layers of information as climate, soil, management/cultivar with regions of interest. The platform uses open source technologies as (MySQL, R, php, JavaScript, Open Layers) and use algorithms of optimization and parallelization to speed up calculations. The platform was used for the "Third National Communication of Climate Change in Argentina for Impact and Adaption in Agriculture".