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4th Annual Global Workshop Poster Abstracts

Assessing Climatic Risk in Rice Productivity Using Integrated Climate, Crop and Economic Modeling Techniques

A. Ahmad et al. 6

Representative Agricultural Pathways and Climate Impact Assessment for Pacific Northwest Agricultural Systems

John Antle et al. 7

TOA-MD: A New Approach to Assess Climate Change Impacts and Adaptation for Agricultural Households

John Antle et al. 8

TOA-MD: A Novel Simulation Approach to Multi-Dimensional Impact Assessment

John Antle et al. 9

Representative Agricultural Pathways and Scenarios: A Trans-Disciplinary Approach to Agricultural Model Inter-comparison, Improvement and Climate Impact Assessment

John Antle et al. 10

Improving Global Agricultural Production by Mitigating Ozone Damages to Crops via Methane Emission Controls and Ozone Resistant Cultivar Selection

Shiri Avnery et al. 11

Global Crop Yield Reductions due to Surface Ozone Exposure: Crop Production Losses and Economic Damage in 2000 and 2030 under Two Future Scenarios of Ozone Pollution

Shiri Avnery et al. 12

Using EPIC for simulating global wheat production: model set-up and future projections

Juraj Balkovič et al. 14

Impacts of projected climate change scenarios on the production and prices of staple and nutritionally important crops in the Southern Africa: project overview

Y. Beletse et al. 15

Integrated assessment of impacts of projected climate change on maize production in the Bethlehem District, Free State, South Africa

Y. Beletse et al. 16

MODEXTREME - MODelling vegetation response to EXTREMe Events

Gianni Bellocchi et al. 17

Sentinel Site Data for Model Improvement and Application – Definitions and Characterization

K. J. Boote et al. 18

Need Across-Models-Across-Crops Testing of Evapotranspiration and Crop Water Use Against Data

K. J. Boote et al. 19

A library of software components for plant airborne diseases simulation

S. Bregaglio et al. 20

Adaptation of a generic fungal plant disease simulator to assess blast disease (*Magnaporthe oryzae* Cav.) impact on rice grown in temperate conditions

S. Bregaglio et al. 21

Biophysical and economic constraints on agricultural intensification in global diet scenarios

Thierry Brunelle et al. 22

Simulation of climate change impacts on rice yield and pre-harvest quality in Latin America

G. Cappelli et al. 23

The Extraction of Double-Cropping Areas in North Korea using Fourier Transform Analysis of Time-series MODIS Imagery

Su-Young Cha et al. 24

AgMIP Potato Pilot: A summary of progress made

Bruno Condori et al. 25

ORACLE: Opportunities and Risks of Agrosystems & forests in response to CLimate, socio-economic and policy changEs in France

Nathalie de Noblet-Ducoudré et al. 26

Enhancing Capacities of the AgMIP South Asia Regional Teams through Capacity-Building Workshops and Knowledge-Sharing Platforms

Guntuku Dileepkumar et al. 28

Enhancing Model Reuse via Component-Centered Modeling Frameworks: the Vision and Example Realizations

Marcello Donatelli et al. 29

Estimating Impact Assessment and Adaptation Strategies under Climate Change Scenarios for Crops at EU27 Scale

M. Donatelli et al. 30

The Global Gridded Crop Model Intercomparison (GGCMI)

Joshua Elliot et al. 31

The 2012 AgMIP/ISI-MIP Fast-Track Assessment

Joshua Elliot et al. 32

Evaluating the utility of dynamical downscaling in large-scale yield assessments

Michael Glotter et al. 33

Climate scenarios for driving AgMIP models

Arthur Greene 34

Climate change adaptations for crop-livestock systems in semi-arid Zimbabwe

Sabine Homann-Kee Tui et al. 35

Anthropogenic Climate Feedbacks via Changes in Crop Productivity

Andrew D. Jones and William D. Collins 36

Modeling the impact of global warming on the sorghum sowing window in distinct climates in Brazil

Flavio Justino et al. 37

Big Data for Big Solutions: Eddy Flux, Mesonet and C Sequestration

Vijaya Gopal Kakani et al. 38

CropBASE: an integrative decision support platform for underutilised crops across research value chains

Asha S. Karunaratne et al. 39

The Influence of Shifting Planting Date on Cereal Grains Production under the Projected Climate Change

Dae-jun Kim et al. 40

Modeling crop yields and yield gaps in Russia, Ukraine and Kazakhstan under climate change

Friedrich Koch et al. 41

Modelling Efforts and Integrated Regional Studies in FACCE MACSUR

Martin Köchy 42

Development and application of a weather data client for preparation of weather input files to a crop model

Chung-Kuen Lee et al. 43

AgMIP Rice Team Activities

Tao Li et al. 44

Progress on the Maize Pilot Study

J.I. Lizaso et al. 46

An Integrated Assessment of Climate Change Impact on Crop Production in the Nioro du Rip Basin of Senegal I: Crop Modelling

D.S. MacCarthy et al. 48

Modeling insect pest distribution under climate change scenarios

A. Maiorano et al. 49

Modelling soil borne fungal pathogens of arable crops under climate change

L.M. Manici et al. 50

Assessing the effects of climate change on current smallholder-subsistence maize production in Southern Africa

Patricia Masikati et al. 51

Critical temperature and sensitivity for white immature rice kernels

Yuji Masutomi et al. 52

The Coordinated Climate-Crop Modeling Project (C3MP): Overview and Protocol Evaluation

Sonali McDermid et al. 53

Integrated assessment of climate change and policy impacts on food security: a case study for protein crop supplies in Austria

Hermine Mitter et al. 54

Assessing Climate Change Impact on Rice Based Farming Systems in Sri Lanka and Adaptation Strategies using DSSAT and APSIM Models

S.P. Nissanka et al. 55

Multi-model simulations for rice yield forecasts in Jiangsu (China)

V. Pagani et al. 56

Integrated Assessment of Climate Change Impacts on Principle Crops and Farm Household Income in Southern India

Paramasivam Ponnusamy 57

A biome-based analysis of current and future global crop yields
T.A.M. Pugh et al. 58

Agricultural processes can substantially affect global climate forcing from CO_2
T.A.M. Pugh et al. 59

Projecting spring wheat yield changes on the Canadian Prairies: Resolutions of a regional climate model
Budong Qian et al. 60

Agricultural impacts of climate variability and change in Eastern Africa
K.P.C. Rao et al. 61

Climate Impact Estimates on C3MP's Worldwide Network of Crop Modeling Sites
Alex Ruane et al. 62

An integrated analysis on Austrian agriculture - climate change impacts and adaptation measures
Martin Schönhart et al. 63

Reimplementation and reuse of the Canegro model: from sugarcane to giant reed
T. Stella et al. 64

Strengthening Simulation Approaches for Understanding, Protecting and Managing Climate Risks in Stress-prone Environments across the Central and Eastern Indo-Gangetic Basin
Nataraja Subash et al. 65

Software frameworks for crop model development and multi-purpose application
A. Topaj et al. 66

Infrared Warming Affects Leaf Gas Exchange and Water Relations of Spring Wheat
G.W. Wall et al. 67

AgMIP Water: Integrating Water Scarcity into Future Agricultural Assessments
Jonathan M. Winter et al. 68

New Drought Indices and Assessment in Drought Monitoring
Nana Yan and Bingfang Wu 69

Irrigation and Rain Fed Croplands Separated Methodology Based on Remote Sensing
Hongwei Zeng et al. 70

The Impacts of Climate Change on Rice Farming Systems in North-Western Sri Lanka
L. Zubair et al. 71

Assessing Climatic Risk in Rice Productivity Using Integrated Climate, Crop and Economic Modeling Techniques

A. Ahmad et al.

Poster position: A2

A. Ahmad, M. Ashfaq, A. Wajid, G. Rasul, T. Khaliq, S. Ahmad, W. Naseem, J. Hussain, M.H. Rahman, U. Saeed, S.A.A. Naqvi and G. Hoogenboom

Rice-wheat cropping zone of Pakistan is facing accelerated incidence rate of extreme weather events. AgMIP-Pakistan is working to quantify the climate change effects on rice crop currently at farm levels using climate, crop and economic models. Five rice producing districts were surveyed and data of 155 farmers were collected for crop and economic models. DSSAT and APSIM were used for crop simulations under present and future climate scenarios. The yield simulations of crop models were obtained separately for baseline (1981-2010) and five future scenarios using 5 GCMs with RCPs 8.5 between 2040 and 2069. The predicted mean data of GCMs showed about 2˚C temperature and 0.13% increase in rainfall till mid-century (2040-2069). The performance of DSSAT was relatively better than APSIM with RMSE (425.46, 440.48 kg ha^{-1}), d-stat (0.784, 0.786) and R^2 (0.52, 0.44), respectively. Models showed a decreasing trend in yield by 30, 20, 13, 7 and 6% (mean 15.2%) in DSSAT and 19, 14, 16, 15 and 18% (mean 17.2%) in APSIM, using five GCMs GFDL, MPI-ESM, CCSM4, MICROS and Had-GEM, respectively. The overall results of TOA-MD model without adaptation showed about 26 and 25 percent gainers for DSSAT and APSIM models, respectively. The results of analysis with adaptation showed that the numbers of adopters would be 64 and 42 percent in APSIM and DSSAT, respectively. Mean net returns per farm were calculated as $2511 and $3728 for without and with-adaptation scenarios for overall APSIM model. Similarly, the mean net returns per farm were calculated as $2505 and $2671 for without and with-adaptation scenarios in case of DSSAT model.

Representative Agricultural Pathways and Climate Impact Assessment for Pacific Northwest Agricultural Systems

John Antle et al.

Poster position: B1

John Antle[1], Elina Mu[2], Hongliang Zhang[3], Susan Capalbo[4], Sanford Eigenbrode[5], Chad Kruger[6], Claudio Stockle[7], J.D. Wolfhorst[8]
[1] Professor of Agricultural and Resource Economics, Oregon State University
[2] Post-doctoral researcher, Agricultural and Resource Economics, Oregon State University
[3] Graduate research assistant, Oregon State University
[4] Professor and Department Head, Agricultural and Resource Economics, Oregon State University
[5] Professor of Entomology and REACCH Project Director, University of Idaho
[6] Director, Center for Sustaining Agriculture and Natural Resources, Washington State University
[7] Professor and Chair, Department of Biological Systems Engineering, Washington State University
[8] Professor, Social Sciences Research Unit, University of Idaho

Representative Agricultural Pathways (RAPs) are projections of plausible future biophysical and socio-economic conditions used to carry out climate impact assessments for agriculture. The development of RAPs is motivated by the fact that the various global and regional models used for agricultural climate change impact assessment have been implemented with individualized scenarios using various data and model structures, often without transparent documentation or public availability. These practices have hampered attempts at model inter-comparison, improvement, and synthesis of model results across. This poster aims to (1) present RAPs developed for the principal wheat-producing region of the Pacific Northwest, and to (2) combine these RAPs with downscaled climate data, crop model simulations and economic model simulations to assess climate change impacts on winter wheat production and farm income. This research was carried out as part of a project funded by the USDA known as the Regional Approaches to Climate Change in the Pacific Northwest (REACCH).

To develop RAPS for the REACCH region, project scientists and other experts with knowledge of the region's agricultural systems are working together through a step-wise process designed to record and document the information used to create RAPS. The REACCH team developed 3 RAPS to represent the future agricultural pathways and scenarios, labeled Business-as-Usual, Dysfunctional World and Aggressive Climate Policy. In each RAP, key variables are identified, narratives are constructed, and quantitative values are assigned. These RAPS are then used by the modeling team to simulate climate change impacts and how technological innovations will help farmers adapt to changing environmental and economic conditions.

TOA-MD: A New Approach to Assess Climate Change Impacts and Adaptation for Agricultural Households

John Antle et al.

Poster position: C1

John M. Antle[1], Roberto O. Valdivia[1*]
[1] Department of Agricultural and Resource Economics, Oregon State University
[*] Corresponding: Roberto.Valdivia@oregonstate.edu

Despite the growing attention paid to the potential for climate change to affect climate variability and extremes, most models being used to assess climate change impacts on agricultural producers are based on averaged or aggregated data over relatively large populations. The only sense in which such studies can assess vulnerability – defined as the risk of a negative impact – is in terms of *average* impacts on groups of farm households stratified by some criterion such as a spatial unit, typically a political unit or an agro-ecozone. In this presentation we present a new economic simulation approach that combines available historical data, statistical models, down-scaled climate data, experimental data and process-based production models, to approximate future distributions of production and associated economic outcomes such as farm net returns. We also show how this model can be used to parameterize an economic impact assessment model, the Tradeoff Analysis Model for Multi-Dimensional Impact Assessment (TOA-MD; Antle 2011; Antle and Valdivia 2011). TOA-MD provides the capability to go beyond the analysis of averaged or aggregated data, by representing the *distributions* of economic, environmental and social outcomes in heterogeneous populations of farm households. When used for climate impact assessment, the TOA-MD model can be used to show how the distributions of outcomes are affected by climate and by adaptations farmers may undertake in response to climate change.

TOA-MD: A Novel Simulation Approach to Multi-Dimensional Impact Assessment

John Antle et al.

Poster position: C2

John M. Antle[1], Roberto O. Valdivia[1*]
[1] Department of Agricultural and Resource Economics, Oregon State University
[*] Corresponding: Roberto.Valdivia@oregonstate.edu

This poster presents a novel approach to impact assessment of agricultural systems which has been implemented as the TOA-MD simulation model. The TOA-MD Model is a unique simulation tool for multi-dimensional impact assessment that uses a statistical description of a heterogeneous farm population to simulate the adoption and impacts of a new technology, a change in environmental conditions, and ecosystem services supply. TOA-MD is a parsimonious approach to impact assessment that is particularly well-suited to ex ante assessment. Unlike conventional ex post statistical or econometric methods that require large, detailed cross-sectional or panel data sets, TOA-MD is designed for ex ante assessment and can be implemented with various types of data, including survey, experimental, and modeled data, together with technological and socio-economic scenarios derived from experts and stakeholders. The poster provides an overview of the approach and the TOA-MD model software, and illustrates the use of the model with results from an application of the model to assess impacts of the adoption of Integrated Agriculture-Aquaculture in Malawi.

Representative Agricultural Pathways and Scenarios: A Trans-Disciplinary Approach to Agricultural Model Inter-comparison, Improvement and Climate Impact Assessment

John Antle et al.

Poster position: C16

John Antle[1], Roberto Valdivia[1*], Lieven Claessens[2], Gerald Nelson[3], Cynthia Rosenzweig[4], Alex Ruane[4], and Joost Vervoort[5]
[1] Oregon State University
[2] International Crops Research Institute for the Semi-Arid Tropics, ICRISAT
[3] International Food Policy Research Institute, IFPRI
[4] NASA Goddard Institute for Space Studies
[5] University of Oxford/CCAFS
[*] Corresponding: Roberto.Valdivia@oregonstate.edu

This poster presents concepts and methods for the development of global and regional Representative Agricultural Pathways and Scenarios that can be used for agricultural model inter-comparison, improvement and impact assessment. These pathways and scenarios are based on the integrated assessment framework developed by the Agricultural Model Inter-comparison and Improvement Project. This framework shows that both bio-physical and socio-economic drivers are essential components of agricultural pathways and logically precede the definition of adaptation and mitigation scenarios that embody associated capabilities and challenges. Based on this approach, we describe a trans-disciplinary process to design pathways and then to translate pathways into scenarios for both bio-physical and economic models that are components of agricultural integrated assessments of climate impact, adaptation and mitigation. To implement this trans-disciplinary approach, we propose a step-wise process similar to the "story and simulation" (SAS) approach to scenario design that brings together expertise from the relevant disciplines to design pathways, and then use these pathways to design consistent scenarios (i.e., model-specific parameters) for crop and livestock simulation models and economic impact assessment models. We present an example of modeling impacts of climate change using the RAPs concept.

Improving Global Agricultural Production by Mitigating Ozone Damages to Crops via Methane Emission Controls and Ozone Resistant Cultivar Selection

Shiri Avnery et al.

Poster position: A4

This poster summarizes the following publication:

Avnery, S, DL Mauzerall, AM Fiore, Increasing global agricultural production by reducing ozone damages via methane emission controls and ozone resistant cultivar selection, *Global Change Biology*, **19**, 1285-1299, doi: 10.1111/gcb.12118, 2013. [full text]

Meeting the projected 50% increase in global grain demand by 2030 without further environmental degradation poses a major challenge for agricultural production. Because surface ozone (O_3) has a significant negative impact on crop yields, one way to increase future production is to reduce O_3-induced agricultural losses. We present two strategies whereby O_3 damage to crops may be reduced. We first examine the potential benefits of an O_3 mitigation strategy motivated by climate change goals: gradual emission reductions of methane (CH_4), an important greenhouse gas and tropospheric O_3 precursor that has not yet been targeted for O_3 pollution abatement. Our second strategy focuses on adapting crops to O_3 exposure by selecting cultivars with demonstrated O_3 resistance. We find that the CH_4 reductions considered would increase global production of soybean, maize, and wheat by 23–102 Mt in 2030 – the equivalent of a ~2–8% increase in year 2000 production worth $3.5–15 billion worldwide (USD2000), increasing the cost effectiveness of this CH4 mitigation policy. Choosing crop varieties with O_3 resistance (relative to median-sensitivity cultivars) could improve global agricultural production in 2030 by over 140 Mt, the equivalent of a 12% increase in 2000 production worth ~$22 billion. Benefits are dominated by improvements for wheat in South Asia, where O_3-induced crop losses would otherwise be severe. Combining the two strategies generates benefits that are less than fully additive, given the nature of O_3 effects on crops. Our results demonstrate the significant potential to sustainably improve global agricultural production by decreasing O_3-induced reductions in crop yields.

Global Crop Yield Reductions due to Surface Ozone Exposure: Crop Production Losses and Economic Damage in 2000 and 2030 under Two Future Scenarios of Ozone Pollution

Shiri Avnery et al.

Poster position: A3

This poster summarizes two publications:

Avnery, S, DL Mauzerall, J Liu, LW Horowitz. Global Crop Yield Reductions due to Surface Ozone Exposure: 1. Year 2000 Crop Production Losses and Economic Damage, *Atmospheric Environment*, 45, 2284-2296, 2011. [full text]

Avnery, S, DL Mauzerall, J Liu, LW Horowitz. Global Crop Yield Reductions due to Surface Ozone Exposure: 2. Year 2030 Potential Crop Production Losses and Economic Damage under Two Scenarios of O3 Pollution, *Atmospheric Environment*, 45, 2297-2309, 2011. [full text]

Exposure to elevated concentrations of surface ozone (O_3) causes substantial reductions in the agricultural yields of many crops. As emissions of O_3 precursors rise in many parts of the world over the next few decades, yield reductions from O_3 exposure appear likely to increase the challenges of feeding a global population projected to grow from 6 to 9 billion between 2000 and 2050. This study estimates year 2000 global yield reductions of three key staple crops (soybean, maize, and wheat) due to surface ozone exposure using hourly O_3 concentrations simulated by the Model for Ozone and Related Chemical Tracers version 2.4 (MOZART-2). We calculate crop losses according to two metrics of ozone exposure - seasonal daytime (08:00-19:59) mean O_3 (M12) and accumulated O_3 above a threshold of 40 ppbv (AOT40) e and predict crop yield losses using crop-specific O_3 concentration:response functions established by field studies. Our results indicate that year 2000 O3-induced global yield reductions ranged, depending on the metric used, from 8.5-14% for soybean, 3.9-15% for wheat, and 2.2-5.5% for maize. Global crop production losses totaled 79-121 million metric tons, worth $11-18 billion annually (USD2000). Our calculated yield reductions agree well with previous estimates, providing further evidence that yields of major crops across the globe are already being substantially reduced by exposure to surface ozone e a risk that will grow unless O_3-precursor emissions are curbed in the future or crop cultivars are developed and utilized that are resistant to O_3.

We examine the potential global risk of increasing surface ozone (O_3) exposure to three key staple crops (soybean, maize, and wheat) in the near future (year 2030) according to two trajectories of O_3 pollution: the Intergovernmental Panel on Climate Change Special Report on Emissions Scenarios (IPCC SRES) A2 and B1 storylines, which represent upper- and lower-boundary projections, respectively, of most O_3 precursor emissions in 2030. We use simulated hourly O_3 concentrations from the Model for Ozone and Related Chemical Tracers version 2.4 (MOZART-2), satellite-derived datasets of agricultural production, and field-based concentration:response relationships to calculate crop yield reductions resulting from O_3 exposure. We then calculate the associated crop production losses and their economic value. We compare our results to the estimated impact of O_3 on global agriculture in the year 2000, which

we assessed in our companion paper [Avnery et al., 2011]. In the A2 scenario we find global year 2030 yield loss of wheat due to O3 exposure ranges from 5.4 to 26% (a further reduction in yield of **.**1.5-10% from year 2000 values), 15-19% for soybean (reduction of +0.9-11%), and 4.4-8.7% for maize (reduction of +2.1-3.2%) depending on the metric used, with total global agricultural losses worth $17-35 billion USD2000 annually (an increase of +$6-17 billion in losses from 2000). Under the B1 scenario, we project less severe but still substantial reductions in yields in 2030: 4.0-17% for wheat (a further decrease in yield of +0.1-1.8% from 2000), 9.5-15% for soybean (decrease of +0.7-1.0%), and 2.5-6.0% for maize (decrease of +0.3-0.5%), with total losses worth $12-21 billion annually (an increase of +$1-3 billion in losses from 2000). Because our analysis uses crop data from the year 2000, which likely underestimates agricultural production in 2030 due to the need to feed a population increasing from approximately 6 to 8 billion people between 2000 and 2030, our calculations of crop production and economic losses are highly conservative. Our results suggest that O_3 pollution poses a growing threat to global food security even under an optimistic scenario of future ozone precursor emissions. Further efforts to reduce surface O_3 concentrations thus provide an excellent opportunity to increase global grain yields without the environmental degradation associated with additional fertilizer application or land cultivation.

Using EPIC for simulating global wheat production: model set-up and future projections

Juraj Balkovič et al.

Poster position: D2

Juraj Balkovič[1], Marijn van der Velde[1], Rastislav Skalský[1], Wei Xiong[1], Nikolay Khabarov[1], Alexey Smirnov[1], Michael Obersteiner[1]
[1] International Institute for Applied Systems Analysis (IIASA), Ecosystem Services and Management Program, Schlossplatz 1, A-2361 Laxenburg, Austria

With a current production of ~700 Mt, wheat is the third largest crop globally, and an essential source of calories in human diets. Sustainable intensification of wheat systems to satisfy rising food demands and the impacts of future climate on wheat yields are widely discussed aspects of securing and sustaining future world wheat production. In this study we present a global EPIC implementation to quantify global wheat production under new generation of climate change scenario. The global modelling system was constructed at 5 arc-min grid by combining the EPIC, v. 0810 model and GIS layers on soils, relief, administrative units, 0.5 arc-deg weather grid, wheat growing periods and fertilizers consumption around 2000 (Mueller et al. 2012). The Princeton weather data were used for the baseline time period (1990 - 2000) and bias-corrected HadGEM2-ES GCM simulations for RCP2.6, 4.5, 6.0 and 8.5 concentration scenarios for the future projections (2041 – 2060, 2081 – 2100). The EPIC model performed satisfactorily in the prediction of average historical wheat yields and production. EPIC simulations with four climate change projections revealed spatially heterogeneous impacts on actually achieved and potential wheat yields across regions and RCP scenarios. From the global perspective and averaged for all RCPs, global wheat production on currently cultivated cropland would likely decrease respectively by 7 and 12% in the 2050s and 2090s because of worsening climatic conditions. There are many differences among regions pointing to spatially differing effects of the climatic drivers on wheat growth.

Impacts of projected climate change scenarios on the production and prices of staple and nutritionally important crops in the Southern Africa: project overview

Y. Beletse et al.

Poster position: B5

Y. Beletse[1], W.Durand[2], O.Crespo[3], C.Nhemachena[6], W.Tesfuhuney[5], M Jones[4], M.Teweldemedhin[7], M.Gamedze[5], P. Gwimbi, T. Mpusaing, PM Bonolo[7], J Siyanda[6] and D Cammarano[8]

[1] Agricultural Research Council-Roodeplaat, KuwaMahlanga road, Pretoria 0001, South Africa
[2] Agricultural Research Council-Small Grain Institute, Potchefstroom, South Africa
[3] Climate System Analysis Group, Environmental and Geographical Science Department, University of Cape Town, 7701 Rondebosch, South Africa
[4] South African Sugarcane Research Institute, 170 Flanders Drive. Mount Edgecombe. KwaZulu-Natal
[5] University of the Free State, PO Box 339 (int 60) Bloemfontein 9300 South Africa
[6] Human Sciences Research Council, Pretorius street, 134 Pretoria, South Africa
[7] Polytechnic of Namibia, Storch Street
[8] Agricultural & Biological Engineering Department, University of Florida, Gainesville, FL 32611, USA

SAAMIIP is a regional AgMIP project with members from South Africa, Lesotho, Swaziland, Botswana and Namibia. The objective of the project is to assess, using climate, crop and economic models, the impacts of projected climate change on agricultural production and socio economics factors in southern Africa. Two crop models (DSSAT and APSIM) were calibrated against detailed field data collected at 'sentinel sites' in each of the countries. Climate dataset for baseline (historical, 1980-2010) and future (2040-2070) was then used by the two crop models to generate a yield change between baseline and future. This information, along with socio economic data and farming communities cropping regions are used as input in the TOA-MD economic model to assess climate change adaptation strategies and their physical and social impacts on farming communities.

The data were gathered from five countries in collaboration with 10 institutions in Southern Africa. The frequent training and the workshops helped the team to clarify the methodologies for using the inputs and for making assumptions for running the climate, crop, and economic models. In addition, the team achieved a better understanding of Regional Agricultural Pathways (RAPs), and the process of developing RAPs for using them in the economic model. Southern Africa is predicted to be affected by increase in temperature and variable rainfall. Without sufficient adaptation measures, the region will likely to suffer negative impacts on several crops that are important in securing food in the region.

Integrated assessment of impacts of projected climate change on maize production in the Bethlehem District, Free State, South Africa

Y. Beletse et al.

Poster position: B6

Y. Beletse[1], W.Durand[2], C.Nhemachena[6], O.Crespo[3], W.Tesfuhuney[5], M Jones[4], M.Teweldemedhin[7], M.Gamedze[5], PM Bonolo[7], and J Siyanda[6]
[1] Agricultural Research Council-Roodeplaat, KuwaMahlanga road, Pretoria 0001, South Africa
[2] Agricultural Research Council-Small Grain Institute, Potchefstroom, South Africa
[3] Climate System Analysis Group, Environmental and Geographical Science Department, University of Cape Town, 7701 Rondebosch, South Africa
[4] South African Sugarcane Research Institute, 170 Flanders Drive. Mount Edgecombe. KwaZulu-Natal
[5] University of the Free State, PO Box 339 (int 60) Bloemfontein 9300 South Africa
[6] Human Sciences Research Council, Pretorius street, 134 Pretoria, South Africa
[7] Polytechnic of Namibia, Storch Street

The impacts of projected climate change on maize production were assessed for 400 maize fields in the Bethlehem District, in the Free State Province, South Africa using climate, crop and economic models. Data used as input by crop and economic models were field crop boundaries, satellite imagery classification, yield surveys, land type classification. Two crop models (DSSAT and APSIM) were calibrated for the local condition using observed climate, soil and agronomic data in the region. Past (1980-2010) and future (5 GCMs for the time period 2040-2070, with RCP8.5 and CO_2 of 571ppm) maize production was simulated and the yield change between future and baseline was determined. The simulated yield changes were used as input into the Trade of Analysis for multi-dimensional impact assessment model (TOA-MD) to characterize the economic impact of climate change. Projections of future changes in climate for South Africa showed an increase in temperature and variability in rainfall, increasing the risk of crop failure and food insecurity in the region. Overall, DSSAT and APSIM simulated a decrease of maize production using projected changes in climate in the region, which will have major implication to food security. The TOA-MD projections showed that about 74% of the farmers in the district would benefit from climate change.

MODEXTREME - MODelling vegetation response to EXTREMe Events

Gianni Bellocchi et al.

Poster position: D12

Gianni Bellocchi[1], Francisco Villalobos[2], Marcello Donatelli[3], Ole B. Christensen[4], Pasquale Steduto[5], Roberto Confalonieri[6], Ioannis N. Athanasiadis[7], Irina Carpusca[8], Claudio Stöckle[9]
[1] Institut National de la Recherche Agronomique (INRA), Clermont-Ferrand, France
[2] Universidad de Córdoba (UCO), Córdoba, Spain
[3] CRA-CIN, Consiglio per la Ricerca e la sperimentazione in Agricoltura, Bologna, Italy
[4] Danmarks Meteorologiske Institut, Copenhagen, Denmark
[5] Food and Agriculture Organization of the United Nations (FAO), Rome, Italy
[6] Università degli Studi di Milano, Milan, Italy
[7] Democritus University of Thrace, Xanthi, Greece
[8] INRA-Transfert, Paris, France
[9] Washington State University, Pullman, United States of America

Extreme weather events are combinations of environmental drivers occurring with a low frequency and negatively impacting on agricultural productions. The project EU-FP7 MODEXTREME (coordination: INRA; grant: 2,000,000 €; start: November 1st, 2013; duration: three years) has the overarching goal to improve the capability of biophysical crop and grassland models by integrating climatic variability and extreme events (mainly high/low temperatures; water deficit/excess). The project includes 18 worldwide partners (seven universities, eight research institutions, one international organization, one software enterprise and one service management society). Generically reusable software units implementing libraries of process models will be created to extend existing modelling capabilities to extreme weather impacts. Estimates from existing and new modelling solutions will be both compared on a variety of datasets and evaluated with respect to medium-term trajectories of future climate. This will be achieved via the multi-model platform for plant growth and development simulations BioMA (The Biophysical Model Application) and will support short- and medium-term forecasts in Europe via the Monitoring Agricultural ResourceS (MARS) workflow of European Commission Joint Research Centre. Project results will also contribute to improve food security monitoring and early warning systems outside Europe (Argentina, Brazil, China, South Africa, United States) via transfer of knowledge to local stakeholders.

Sentinel Site Data for Model Improvement and Application – Definitions and Characterization

K. J. Boote et al.

Poster position: C3

K. J. Boote[1], C. H. Porter[2], J. W. Jones[2], P. J. Thorburn[3], and G. Hoogenboom[4]
[1] Agronomy Dept., University of Florida, Gainesville, FL 32611
[2] Agric and Biol. Engr. Dept., University of Florida, Gainesville, FL 32611
[3] CSIRO, Brisbane, Australia
[2] Washington State University, Prosser, WA

Quality experimental data are a necessary pre-requisite for use by crop modelers in order to calibrate, evaluate, and improve models for ability to respond to climatic change factors of carbon dioxide, temperature, precipitation and the interaction with management and genetic factors. Here we describe criteria for characterizing the quality, quantity, reliability/accuracy, and value of measured crop, soil, weather, and management data for modeling purposes. AgMIP is establishing a data base for storage of crop, soils, and weather data to be used for running and testing of models. The data sets are categorized as platinum, gold, silver, or copper based on quality. Platinum indicates highest quality observed data for model evaluation, and improvement, with a full complement of variables including in-season and end-of-season crop growth and yield measurements, with observed site-specific data on soil, weather, and management conditions for model inputs. The second-tier 'gold sentinel' sites have sufficient information for model calibration and evaluation, but lack the breadth of variables or intensity of data available, and weather or soil data may not be measured on-site. The third-tier 'silver sentinel sites' is characteristic of yield trials that plant breeders manage, where end-of-season yield is measured, along with management inputs of planting date, irrigation, and fertilization. However, in-season measurements and phenology are lacking, and weather and soil data are not site-specific. Copper sentinel sites have fair quality data such as site-specific farm survey yields or variety trial yields, but local weather and soil information are not available and some management data are approximated.

Need Across-Models-Across-Crops Testing of Evapotranspiration and Crop Water Use Against Data

K. J. Boote et al.

Poster position: C4

K. J. Boote[1], Co-Coordinator, AgMIP Crop Modeling, assisted by AgMIP-Maize, AgMIP-Wheat, and Global Gridded Modelers
[1] Dept of Agronomy, University of Florida, Gainesville, FL 32611

All crop models, whether site-specific or global-gridded and regardless of crop, simulate daily crop transpiration and soil evaporation during the crop life cycle, resulting in seasonal crop water use. Modelers use several methods for predicting daily potential evapotranspiration (ET), including FAO-56, Penman-Monteith, Priestley-Taylor, Hargreaves, full energy balance, and transpiration water efficiency. They use extinction equations to partition energy to soil evaporation or transpiration, depending on leaf area index. Most models simulate soil water balance and soil-root water supply for transpiration, and limit transpiration if water uptake is insufficient, and thereafter reduce dry matter production. Intercomparisons of multiple crop and global gridded models in AgMIP show surprisingly large differences in simulated ET and crop water use for the same climatic conditions. Unfortunately, model intercomparison alone is not enough to know which models are correct. There is an urgent need to test these models against field-observed data on ET and seasonal crop water use. Because water resources are so important for production, it is crucial that we establish a new effort across all crops and across models, with the goal of testing and improving the models for predicting ET and crop water use. Two types of data include: 1) season-long water use computed from soil-water balance where runoff and deep percolation are known or zero, 2) instantaneous transpiration-soil evaporation measured by lysimeters, Bowen ratio, and eddy flux systems. Special emphasis should be placed on using available FACE data to test simulated reduction in transpiration with rising CO_2.

A library of software components for plant airborne diseases simulation

S. Bregaglio et al.

Poster position: A13

S. Bregaglio[1], M. Donatelli[2], R. Confalonieri[1]
[1] Dep. of Agricultural and Environmental Sciences - Production, Landscape, Agroenergy, University of Milan, Milan, Italy
[2] CRA-CIN, Consiglio per la Ricerca e sperimentazione in Agricoltura, Bologna, Italy

The importance of including the impacts of plant diseases in crop production simulation studies is widely recognized, although an explicit coupling of disease forecasting models with crop growth models is still not operational. The increasing adoption of component-oriented programming in agro-ecological modelling could lead to fill this gap, thanks to the handling of the high complexity of the simulated biophysical processes. This work presents four independent software components aimed at simulating a generic polycyclic fungal epidemic, which can be extended with alternate approaches and reused under diverse modelling platforms. These components provide options for simulating the initial conditions of an epidemic, the progress of the disease over time driven by meteorological variables, the yield losses due to the pathogen impact and the agro management practices to reduce disease development. This platform was parameterized for wheat brown rust and rice blast disease and coupled to two crop simulators (WOFOST and WARM). These modelling solutions were evaluated via a spatially distributed sensitivity analysis exercise to gain an in-depth knowledge about model functioning and to obtain information about possible reduction or simplifications. The results indicated that the modelling solutions were sensitive to diverse parameters according to the pathogen simulated and coherent about the small relevance of parameters belonging to same processes in the two pathosystem tested. The framework presented here represents one step to move beyond both statistical models and a misuse of process based model via calibration which leads only to data fitting, instead of forecasting models.

Adaptation of a generic fungal plant disease simulator to assess blast disease (*Magnaporthe oryzae* Cav.) impact on rice grown in temperate conditions

S. Bregaglio et al.

Poster position: A14

S. Bregaglio[1], P. Titone[2], G. Cappelli[1], L. Paleari[1], L. Tamborini[2], M. Donatelli[3], R. Confalonieri[1]

[1] Dep. of Agricultural and Environmental Sciences - Production, Landscape, Agroenergy, University of Milan, Milan, Italy
[2] CRA-SCS, Consiglio per la Ricerca e sperimentazione in Agricoltura, Lodi, Italy
[3] CRA-CIN, Consiglio per la Ricerca e sperimentazione in Agricoltura, Bologna, Italy

The blast disease (*Magnaporthe oryzae*) is the primary constraint of rice production worldwide and it is present in more than 85 countries, causing severe epidemics especially in paddy rice grown in temperate regions. Yield losses are around 10-30% of the total world production. Since years researchers started developing models to forecast the evolution of blast epidemics and to support farmers in the scheduling of fungicide sprays. Most of the available models were evaluated in Asian rice growing areas and only in few cases they were coupled with rice simulators to consider blast impact on leaf area and biomass accumulation, to obtain the quantification of yield losses. This work presents the adaptation of a generic platform for the simulation of blast epidemics and its coupling with a rice crop model. The modelling solution was run in Italian rice cultivated areas (first European producer) by considering multiple years and cultivars. The number of disease assessments was 274, organized in a scale ranging from 0 to 5. Results showed good performances both in calibration and evaluation datasets (R^2=0.813 and 0.783, respectively), clearly indicating its suitability in responding to the heterogeneity of the agro-meteorological conditions explored. When converted to ordinal values, the simulated blast impacts matched visual assessments in 50.3% of cases, and in 37.6% they missed reference values by one rank. Given the massive datasets used for its evaluation, this modelling solution will be applied in climate change scenarios to assess the potential future impact of blast disease on European rice productions.

Biophysical and economic constraints on agricultural intensification in global diet scenarios

Thierry Brunelle et al.

Poster position: A9

Thierry Brunelle, François Souty, Patrice Dumas and Bruno Dorin

Globalization drives a process of diet convergence, and in so doing increases the uncertainy about future patterns of food consumption. To address this issue we map the range of possible future diet changes and explore their impact on agriculture using the Nexus Land Use model. Four scenarios built on distinct assumption on the diet convergence process depict very contrasting visions on agricultural systems in 2050. The study focuses on agricultural intensification, taking into account economic and biophysical constraints. A non-linear response of fertilizer on cropland and a potential yield limit allows to represent decreasing returns of fertilizer application at high yields. Land-use change is driven by a trade-off between the extensive system with grazing ruminants, established on the lands with lowest fertility, and the intensive system with mixed livestock and cropland. To assess the accuracy of model results, the model ability to reproduce past observations is evaluated through a backcasting exercise.

Simulation of climate change impacts on rice yield and pre-harvest quality in Latin America

G. Cappelli et al.

Poster position: C14

G. Cappelli[1], S. Bregaglio[1], M. Donatelli[2], R. Confalonieri[1]
[1] Dep. of Agricultural and Environmental Sciences - Production, Landscape, Agroenergy, University of Milan, Milan, Italy
[2] CRA-CIN, Consiglio per la Ricerca e sperimentazione in Agricoltura, Bologna, Italy
[3] University of East Anglia

Despite the large availability of models simulating crop growth and development, few operational approaches have been developed to assess pre-harvest quality of agricultural productions. This represents a clear gap of knowledge researchers are trying to fill, in light of the evidences of a climate change-driven decline in nutritional properties of important food crops, with direct implications on the economic value of productions and on food security issues. This contribution presents an assessment of pre-harvest rice quality under different climate change scenarios in Latin America. Simulations were performed using the BioMA platform, in which the WARM rice model was linked to modelling approaches simulating grain amylose and protein contents, and the occurrence of chalkiness and fissured grains. Simulations were performed at 25×25 km spatial resolution for all the Latin American rice districts and results were aggregated at national level. Despite some differences due to emission scenarios and general circulation models, simulations revealed an overall maintenance of current production levels, whereas a general decay of quality variables is expected, especially in countries where severe climatic anomalies are foreseen (Brazil and Mexico). The negative impact on quality will be more relevant for *Japonica* cultivars compared to *Indica* ones, coherently with the different thermal requirements for starch synthesis for the two ecotypes. Our projections also indicate that climate change will lead to positive effects in countries where rice will explore conditions of better adaptation, like in Chile. This analysis demonstrated the usefulness of approaches to simulate quality variables and their potential for defining effective adaptation strategies to alleviate the expected decline in rice quality.

The Extraction of Double-Cropping Areas in North Korea using Fourier Transform Analysis of Time-series MODIS Imagery

Su-Young Cha et al.

Poster position: D9

Su-Young Cha[1], Chong-Hwa Park[2], Yeo-Chang Youn[3]
[1] Research Institute for Agriculture and Life Sciences, Seoul National University
[2] Graduate School of Environmental Studies, Seoul National University
[3] Department of Forest Sciences, Seoul National University

Human-induced forest alterations in North Korea have been expanded by the severe food crisis. Many forests have been converted into cropping area. It is important to know such deforested area in North Korea, which is not easy to access by direct field survey. Here we developed a method to get the deforested area. The double cropping area, where the NDVI (Normalized Difference Vegetation Index) has double maxima in a year is the evidence of the human farming. Such double cropping area has been detected through the Fourier analysis of the time-series MODIS (Moderate Resolution Imaging Spectroradiometer) data from 2000 to 2009. The intensity of the second harmonics, i.e., the bimodal NDVI component is directly related to the double cropping areas. Crop information of South Korea was used to access the accuracy of the result. We did not find the double cropping area only in the western field area but also on the mountainous area. The Daehongdangun region known as a large collective farm in North Korea showed strong second harmonics. The methodology used in this study is useful for detecting the deforested area that is used for the double cropping in North Korea.

AgMIP Potato Pilot: A summary of progress made

Bruno Condori et al.

Poster position: C7

Bruno Condori, Carolina Barreda, David Fleischer and Roberto Quiroz

The potato crop (*Solanum sp.*) has a substantial social and economic importance for many developing and developed countries. This crop is dispersed around the world, growing in very high contrasting environments: from 0 to 4000 meters above sea level, latitudes from 65° to -40°, and photoperiods ranging from 12 to 15 hours. The potato cropping systems are quite variable spanning from rain-fed low input conditions to high-tech precision agriculture. A striking difference with other crops of global importance is the variation in the cultivated ploidy (2x=24, 3x=36, 4x=48 and 5x=60), conferring the crop a wide adaptation range and thus adding complexity to the assessment of the response to climate variability and change. The AgMIP potato is a new pilot of the international effort that links the climate, crop, and economic modeling communities with cutting-edge information technology to produce improved crop and economic models and the next generation of climate impact projections for the agricultural sector. So far, 28 researchers and 10 potato modeling groups have agreed to become part of this initiative. Furthermore, five sentinel sites have been selected in Bolivia, Peru, Burundi, Denmark and USA. A preliminary analysis of the yield statistics around sentinel sites - 10 to 100 tons of fresh tubers per hectare – summarizes the challenges that the trans-disciplinary team will face.

ORACLE: Opportunities and Risks of Agrosystems & forests in response to CLimate, socio-economic and policy changEs in France

Nathalie de Noblet-Ducoudré et al.

Poster position: B4

Nathalie de Noblet-Ducoudré, Iñaki Garcia de Cortazar Atauri, Julie Caubel, Anne-Isabelle Graux, Sophie Wieruszeski, Dominique Carrer, Jean-Christophe Calvet, Nabil Laania

ORACLE aims at providing spatially-gridded assessments of potential future changes in a) the functioning of agro-ecosystems, b) land uses in France at rather high resolution (8 x 8 km2). These assessments involve the production of tools and data to study the relationships between climate change and possible changes in land use, together with the impacts of changing policies. We will focus our analysis and modeling on the main components of the non-urban land use, namely crops, grasslands and forests. We will study their production as well as their environmental functionalities (GHG emission, hydrology, soil carbon storage) and develop a small set of relevant indicators. Climate-induced changes in those indicators will be analyzed and, wherever possible, their upper and lower limits will be defined. This will allow us to assess, per grid-cell, risks of dis-functioning of specific systems, potential disappearance of present-day land-uses, and potentialities of appearance of new ones. We will also try to combine the indicators with water availability to identify potential future hot-spots in France and Europe, i.e., grid-cells or regions that may experience drastic land-use changes.

Insights on land-use change will be obtained following two parallel methodologies. First, we will use the climatically-induced variations of the above-mentioned indicators to explore reshaping of farming systems, optimizing opportunities and minimizing constraints, without accounting for changes in socio-economic drivers. The propositions will rely on a) meta-analysis of published data on agronomic performances and environmental impacts of cultivation systems, and b) expert knowledge.

In the second methodology, we will jointly evaluate the impacts of changes in climatic and socio-economic drivers on anthropogenic land-uses. We will rank those impacts and identify areas where the impacts of climate change on land-uses may overrule those resulting from socio-economic changes. We will also attempt to estimate land-use change between agriculture and forest when both climatic and economic drivers change.

Results will be obtained i) at two spatial scales, namely France and hydrological basin (Seine and Leyre basins), ii) for two time horizons (2020-2050 and 2070-2100) in reference to the 1970-2000 period. Both prospective uncertainty (socio-economic scenarios, crop or forest management) and epistemic uncertainty (due to imperfect knowledge within models) will be analyzed at various levels through multi-model and multi-scenario approaches and appropriate statistical analysis. Results of the uncertainty analysis will be used as an input for modeling anticipative adaptation decisions in the economic models.
In terms of methodology, the main idea of the project is to rely on well-known models (global vegetation models, agronomic and forest models, economic models) and on published experimental data, and profit from existing methods (climate downscaling, meta-analysis,

indicator reckoning...) and databases developed within the framework of previous projects on climate change impacts, in an integrated and coordinated way.

ORACLE is a true multi-disciplinary project that brings together climatologists, crop and forest scientists, economists, hydrologists and statisticians who have an experience in climate change issues at various scales.

Enhancing Capacities of the AgMIP South Asia Regional Teams through Capacity-Building Workshops and Knowledge-Sharing Platforms

Guntuku Dileepkumar et al.

Poster position: B2

Guntuku Dileepkumar, Dakshina Murthy Kadiyala, S. Nedumaran, Piara Singh, Raji Reddy, P Paramasivam, V Geethalakshmi, B Gangwar, N Subash, Ashfaq Ahmad, Lareef Zubair, S.P. Nissanka, V Sumanthkumar, Cynthia Rosenzweig, Jim Jones, John Antle, Carolyn Mutter

Agricultural systems are sensitive to extreme climatic events such as droughts, floods, delayed onset of monsoon, intermittent dry spells, heat and cold waves. The impact of these events is felt by regional agricultural systems differently based upon their climate, environment and socio economic conditions. Although there are many initiatives in progress to address the impacts of climate change all over the world but there are very few focusing on analysing impacts of climate variability and change through a transdisciplinary effort that consistently linking state-of-the-art climate scenarios to crop and economic models. The Agricultural Model Intercomparison and Improvement Project (AgMIP) is such initiative at global level linking climate, crop, and economic modeling communities with cutting-edge information technology to produce improved crop, and economic models and the next generation of climate impact projections for the agricultural sector.

The AgMIP South Asia Coordination Research Team (SA-CRT) ensures enhancing capacities of South Asia AgMIP Regional Research Teams in coordination with AgMIP Global team. The main goals of AgMIP South Asia CRT team are (1) enhance capacities of the multi-disciplinary research teams throughout the region and prepare them for integrated assessments of climate change impacts and adaptations (2) helps in designing workshops to publish the results of the integrated assessments that each research team has put together during the project. In addition, the SA-CRT also aims to develop knowledge-sharing platforms so as to facilitate learning exchanges among and across the various AgMIP regional teams of South Asia and also ensure the national systems and various stakeholders utilizing the benefits of AgMIP research results.

In this paper the authors present the innovative capacity building and knowledge sharing platforms designed during the project period and their implications to meet the goals and objectives of AgMIP.

Enhancing Model Reuse via Component-Centered Modeling Frameworks: the Vision and Example Realizations

Marcello Donatelli et al.

Poster position: D11

Marcello Donatelli[1], Iacopo Cerrani[2], Davide Fanchini[2], Davide Fumagalli[2], Andrea Emilio Rizzoli[3]
[1] CRA-CIN, Consiglio per la Ricerca e Sperimentazione in Agricoltura, Bologna, Italy
[2] JRC IES, European Commission, Ispra (VA), Italy
[3] Dalle Molle Institute for Artificial Intelligence, Manno, Switzerland

Model frameworks have represented a substantial step forward with respect to monolithic implementations of biophysical models. However, the diffusion of such frameworks, as model development environment, beyond the groups developing them has been very modest. The reusability of models has also proved to be modest. The reason for the latter was attributed also to the lack of standardization toward few frameworks. Emphasis has been placed on the framework and even new implementations of models have been made targeting a specific framework, likely assuming that the reusability of the model unit would have been directly proportional to the quality of the framework. In any case, the goal of several projects has been to make available the framework. Developers in the operational arena, but even in research, have reacted by developing their own framework. Still, the problem of model reuse has been largely unsolved; estimating that increasing the flexibility for reuse would have added a costly overhead, in terms of both complexity and possibly as lack of efficiency in the operational use. The focus on frameworks has made software architects overlooking on the requirements of reusability per se of model units. The component oriented programming paradigm allows targeting intrinsic reusability of discrete model units, and makes room for enabling advances functionalities in simulation systems. This paper firstly present the abstract architecture of a component oriented framework articulated in independent layers: Model, Composition, and Configuration. The Application layer may link to any of these, to develop from simple console applications to sophisticated MVC applications. Proofs of concept are presented for each layer, including the BioMA framework of the European Commission used for agriculture and climate change studies.

Estimating Impact Assessment and Adaptation Strategies under Climate Change Scenarios for Crops at EU27 Scale

M. Donatelli et al.

Poster position: A1

M. Donatelli[1], A.K. Srivastava[2], G. Duveiller[2], S. Niemeyer[2]
[1] CRA-CIN, Consiglio per la Ricerca e Sperimentazione in Agricoltura, Bologna, Italy
[2] JRC IES, European Commission, Ispra (VA), Italy

Policy makers at European and national level demand for estimates of potential vulnerability of agricultural production. Estimates are requested specific to province level, and articulated for crops. The base of such estimates is the biophysical representation of crop responses both under conditions of no adaptation, and exploring the level of adaptation which could be acted on autonomously by farmers. However, producing such estimates poses significant challenges due to the usability of climate inputs to simulation models, to reliability and completeness of data, to the level of abstraction to be chosen, and to technological aspects. This study provides an impact assessment of climate change scenarios on agriculture over EU27 focused on the time horizons of 2020 and 2030 with respect to a baseline centered on the year 2000. Potential and water-limited yields are simulated for 3 priority crops (wheat, rapeseed and sunflower) over a 25 by 25 km grid using the CropSyst model implemented within the BioMA modelling platform of the European Commission. Input weather data are generated with a stochastic weather generator parameterized over RCM-GCM downscaled simulation from the ENSEMBLES project, which have been statistically bias-corrected. Two realizations of the A1B emission scenario within ENSEMBLES are used, based on the HadCM3 and ECHAM5 GCMs, which respectively represent the “warmer” and “colder” extremes in the envelope of the ensemble with regard to the air temperature trends, and different with respect to rainfall patterns. Alleviating the consequences of unfavorable weather patterns is explored by simulating technical operations which can be acted on by farmers, highlighting the limits of autonomous adaptation, hence estimating potential vulnerability hotspots. Data are presented focusing on the difference between the baseline chosen and the 2020 and 2030 time horizons. Both data (accessible via web services) and the simulation platform are available for non-commercial use.

The Global Gridded Crop Model Intercomparison (GGCMI)

Joshua Elliot et al.

Poster position: D5

Joshua Elliott[1], Christoph Muller[2], and Delphine Deryng[3]
[1] University of Chicago, Argonne National Lab, and Columbia University
[2] Potsdam Institute for Climate Impact Research
[3] University of East Anglia

Initial results from the 2012 AgMIP/ISI-MIP Fast-Track assessment indicate the potential of global gridded crop model simulations and the need to further improve understanding of mechanisms, assumptions, and uncertainties of model design and execution; these are best addressed in a coordinated model intercomparison project at continental and global scale. In Spring 2013, we developed a new set of protocols for the GGCMI, which will run for 3 years and include 3 overlapping phases of increasing duration: 1) Historical simulation and model evaluation, 2) Analysis of model sensitivity to CTWN (carbon, temperature, water, and nitrogen), and 3) Coordinated regional and global climate assessment.

In this poster we summarize the protocols for the three phase project and present preliminary results from Phase 1 of the GGCMI: Historical simulation and model evaluation. In this stage, models are being run using various observation and reanalysis-based historical weather products so that they can be evaluated over the historical period globally and in various key interest regions. The project currently includes ~18 modeling groups from 11 countries, along with several other major data partners, and simulations are being performed over the Summer and Fall of 2013.

The 2012 AgMIP/ISI-MIP Fast-Track Assessment

Joshua Elliot et al.

Poster position: D6

Joshua Elliott[1], Christoph Muller[2], Delphine Deryng[3], Jerry Nelson[4], Franziska Piontek[5], and Cynthia Rosenzweig[6]
[1] University of Chicago, Argonne National Lab, and Columbia University
[2] Potsdam Institute for Climate Impact Research
[3] University of East Anglia
[4] University of Illinois at Urbana-Champaign
[5] Potsdam Institute for Climate Impact Research
[6] NASA GISS

In 2012 AgMIP led a Global Gridded Crop Model (GGCM) Intercomparison Fast-Track project in coordination with the PIK-led Inter-Sectoral Impacts Model Intercomparison Project (ISI-MIP). This fast-track included 7 GGCMs and updated the state of knowledge on climate change vulnerabilities and impacts using modern global high-resolution models driven by climate model output from CMIP5. This fast-track culminated with the January 31st submission of 6 papers to a PNAS special issue, of which 5 are accepted or are in revision (3 accepted in time to meet deadlines for inclusion in IPCC AR5). In this poster we summarize each of these papers along with key findings from the 2012 Fast-Track assessment.

Evaluating the utility of dynamical downscaling in large-scale yield assessments

Michael Glotter et al.

Poster position: D7

Michael Glotter, Joshua Elliott, Alex Ruane, and Elisabeth Moyer

Because agricultural yield is highly sensitive to climate variability, yield projections require high spatial and temporal resolution weather products. Recently, multiple projects have combined GCM output with regional climate model (RCM) simulations to produce fine-scale (dynamically downscaled) climate projections to drive climate impact models. We investigate here whether these computationally intensive practices improve or affect large-scale crop yield estimates under future climate change. We drive a parallelized version of the DSSAT crop model for the continental United States with climate products from the NARCCAP regional climate model comparison project, using different GCMs both with and without dynamical downscaling. We find that once applying a relatively simple (but necessary) bias correction, there is little significant difference between crop yields whether driven by simply interpolated GCM output or by dynamically downscaled climate. Our results suggest that computationally intensive downscaling practices likely lend little additional value in agricultural impact applications. Yield projections under climate change may instead benefit most from improved observational climate data, especially in the developing world where data is scarce and modelers are often forced to rely on reanalyses (models nudged by observed atmospheric data). Reanalysis model output has significant flaws, however, and initial results suggest that observed precipitation is necessary for accurate agricultural yield estimates. Improving precipitation measurements in the developing world may be a critical part of estimating future food supply under climate change.

Climate scenarios for driving AgMIP models

Arthur Greene

Poster position: D8

Arthur Greene[1]
[1] International Research Institute for Climate and Society, Earth Institute at Columbia University, Palisades, New York, USA

We present a method for the generation of stochastic simulations on "near-term climate change" (i.e., decadal) time horizons, designed for driving models participating in AgMIP. In the absence of skillful decadal forecasts (particularly over land regions), such simulations provide a useful means of characterizing climate uncertainty and modeling its propagation through agricultural and ultimately, economic systems. The method involves the combining of information from various sources, including global climate models, local observational records and current research results. The climate models provide large-scale and long range information on climatic trends, while local observational records are employed for the characterization of higher-order variability. Both parametric and nonparametric techniques are employed in the merging of information. Example simulations are provided for selected regions, and issues that arise in simulation generation are described.

Climate change adaptations for crop-livestock systems in semi-arid Zimbabwe

Sabine Homann-Kee Tui et al.

Poster position: B15

Sabine Homann-Kee Tui[1], Patricia Masikate[1], Katrien Descheemaker[3], Lieven Claessens[2], Olivier Crespo[4], Andre van Rooyen[1], Roberto Valdivia[5]
[1] International Crops Research Institute for the Semi-Arid Tropics (ICRISAT, www.icrisat.org), PO Box 776, Bulawayo, Zimbabwe, and [2] PO Box 39063, Nairobi, Kenya
[3] Wageningen University, Plant Production Systems Group, Wageningen, The Netherlands
[4] University of Cape Town, Climate Systems Analysis Group (CSAG), Cape Town, South Africa
[5] Oregon State University, Corvallis, Oregon

We present preliminary results of the Crop-Livestock Intensification Project (CLIP), answering AgMIP's three core questions: Potential impact of climate change (CC) on future agricultural systems and economic impacts of CC adaptation strategies. We focus on smallholder crop-livestock systems in semi-arid Zimbabwe. Maize is the predominant crop, with low yields (average 650kg/ha). Livestock productivity is also low; dry season feed shortages are major bottleneck. Two adaptation strategies were compared: 1. Crop intensification through fertilizer applications (0, 18 and 52 N kg/ha), 2. Systems shift towards livestock by introducing maize-mucuna rotation.

Climate simulations between current (1980-2010) and mid-century climate scenarios (2040-2070), for 5 selected GCMs project increasing temperatures (+2 - +3.3^{o}C), but future rainfall is uncertain. Crop simulations (APSIM) suggest that maize yields can decrease by more than 20%, fertilizer and mucuna can offset these effects. Livestock simulations (LIVSIM) suggest marginal CC effects on livestock; fertilizer and maize-mucuna rotation can increase livestock productivity. The effects of GCMs on crops and livestock production are not consistent.

The TOA-MD economic ex-ante impact assessment, using household survey data and combined with RAPs developed through stakeholder consultation, indicates small CC effects on entire farms and heterogeneous farm populations in semi-arid Zimbabwe. Maize-mucuna rotation was identified as the more CC resilient adaptation strategy, providing higher farm net returns against less risk, compared to fertilizer applications. Economic benefits on the poor will however be minimal. More drastic systems shifts towards diversified and better integrated farming systems are required to sustain food security and move farms above poverty thresholds

Anthropogenic Climate Feedbacks via Changes in Crop Productivity

Andrew D. Jones and William D. Collins

Poster position: A10

Andrew D. Jones[1], William D. Collins[1]
[1] Lawrence Berkeley National Laboratory

Climate change has the potential to impact agricultural productivity through multiple mechanisms. To the extent possible, farmers will respond to these changes by altering management practices and shifting the geographic distribution of various crops. Meanwhile, climate mitigation measures are placing unprecedented demands on agricultural systems for the provision of bioenergy. Such changes in land use and landcover are known to impact climate at both regional and global scales through changes in carbon storage and through direct physical consequences of landcover change. Yet, the current generation of 21st century climate projections (the CMIP5 RCP scenarios) do not account for dynamic land-use feedbacks. To address this gap, we are developing a new coupled model framework, the Integrated Earth System Model (iESM), which links the human decision making elements of an integrated assessment model with the physical and ecosystem components of a state-of-the-art global climate and earth system model.

Key to capturing agricultural land-use responses to climate change within this framework is the development of a new crop model for the Community Land Model (CLM) capable of representing bioenergy crops. Preliminary results demonstrate the ability of this model to reproduce seasonal leaf area index dynamics for C4 perennial biofuel crops grown in North America. We have also conducted a sensitivity analysis to identify which parameters of the model yield meaningful changes in the simulation of climatically relevant variables such as surface energy and water fluxes, and soil carbon storage.

Modeling the impact of global warming on the sorghum sowing window in distinct climates in Brazil

Flavio Justino et al.

Poster position: C11

Flavio Justino[1], Marine Cirino Grossi[1], Camilo de Lelis Teixeira Andrade[2], Eduardo Alvarez Santos[1], Rafael Avila Rodrigues[1], and Luiz C. Costa[1]
[1] Departamento de Engenharia Agricola, Universidade Federal de Viçosa, PH Rolfs 36570 000, Viçosa, MG, Brazil
[2] Empresa Brasileira de Pesquisa Agropecuária, Centro Nacional de Pesquisa de Milho e Sorgo., Rod. MG 424, Km 45, Zona Rural, 35701970 - Sete Lagoas, MG, Brazil

F. Justino[1], M. Grossi[1], C. Lelis[2], E. Santos[1], R. Rodrigues[1] and L. Costa[1]

This poster presents recent result published by the European Journal of Agronomy.
http://www.sciencedirect.com/science/article/pii/S1161030113000919

This study aims to calibrate, and validate the CSM-CERES-Sorghum model and to investigate the vulnerability of sorghum yield for current (1982-1999) and future (2047-2064) epochs, by applying weather observations and climate outputs based on ECHAM, CCCma and GFDL models. Field experiments have been conducted in the experimental area of Janaúba and Sete Lagoas located in Minas Gerais State, Brazil. It has been found that the CSM-CERES-Sorghum model reasonably simulates crop phenology, crop biomass production, leaf area and yield components that are crucial to ensure the model reliability to reproduce in situ conditions. Comparison between the CSM-CERES-Sorghum results driven by the climate models and baseline observations shows that the ECHAM better reproduces the current observations. However, inaccurate results are found by utilizing the GFDL climate primarily due to lower precipitation values. This is found for both cities. Turning to future conditions, the simulations indicated that in Janaúba the average yields for current and future climate conditions were not statistically different, but in Sete Lagoas, there was a statistically significant increase in the sorghum productivity in the latter scenario. Moreover, it has been found that the simulations using the 52 sowing dates indicated that climate change modifies the grain yield projecting a delay in the most favorable planting date. According to the results the seeding of sorghum will very likely be held later in both cities.

Big Data for Big Solutions: Eddy Flux, Mesonet and C Sequestration

Vijaya Gopal Kakani et al.

Poster position: D13

Vijaya Gopal Kakani[1], Kundan Dhakal[1], Pradeep Wagle[1]
[1] Department of Plant and Soil Sciences, Oklahoma State University, Stillwater, OK

Bioenergy holds potential to positively contribute to economic and environmental well-being at farm and global scale. Quantification of C sequestration by bioenergy cropping ecosystem can be of great importance as measured ecosystem level CO2 fluxes can be extrapolated to estimate the regional carbon balance and simulate future atmospheric CO2 concentrations. Eddy flux systems provide continuous data on crop CO2 and H2O response to its environment. Weather networks such as Mesonet (www.mesonet.org) in Oklahoma provide high quality environmental data across the state. A combination of eddy flux and Mesonet data streams can provide estimates of regional C sequestration. The objectives of the study were to (1) characterize the effects of key environmental factors on daytime NEE and to explore the underlying mechanisms, (2) identify potential switchgrass production areas across the State of Oklahoma, (3) conduct seasonal (April to August) spatial modeling of net ecosystem exchange (NEE) of C across potential switchgrass production area. Study window was limited to the active growing season. Potential switchgrass production areas in Oklahoma were identified from the USDA-NASS Cropland Data Layer (CDL). Mesonet data was checked thoroughly and processed to calculate 30-minute average values. Temperature response curves were developed for NEEsat, apparent quantum efficiency (AQE), day and night respiration based on eddy-covariance measurements at Chickasha, OK in 2011. The 30 min NEE values were generated as a function of NEEsat, PPFD and AQE for entire Oklahoma. The results of this study are useful for the modeling community to develop, improve, and validate the models for global climate change studies.

CropBASE: an integrative decision support platform for underutilised crops across research value chains

Asha S. Karunaratne et al.

Poster position: C10

Asha S. Karunaratne[1,2], Sayed Azam-Ali[1], Sue Walker[1]
[1] Crops For the Future Research Centre (CFFRC), c/o University of Nottingham, Malaysia Campus, Semenyih, Selangor, Malaysia
[2] Faculty of Agricultural Sciences, Sabaragamuwa University, Belihuloya, Sri Lanka

CFFRC is the world's first centre for research on underutilised crops for food and non-food uses. From its headquarters near Kuala Lumpur, Malaysia, CFFRC is building a global stakeholder alliance of education, public, private and civil society partners for research on underutilised crops. CFFRC activities focus around five research 'themes' that provide a `Research Value Chain' of facilities and expertise on underutilised crops spanning plant genomics to applied social sciences.

CFFRC also has six research 'programmes' of which CropBASE provides an underpinning knowledge system and web-based platform for decision support and knowledge sharing on underutilised crops and their end uses. CropBASE will provide a quantitative basis to compare underutilised crop productivity and resource use efficiency with those of major crops and cropping systems under current and future climate scenarios. To provide such comparisons, CropBASE is developing interactive tools that integrate novel data on underutilised crops with geo-referenced information in existing and new databases.

The main analysis engine of CropBASE involves crop-climate modelling that introduce specific underutilised crops into recognised crop models (APSIM, AquaCrop, DSSAT) and link available climate databases within a geospatial information system framework. This poster presents a preliminary use-case scenario of bambara groundnut (an underutilised African legume) genotypes under baseline and future climate scenarios. By using contrasting African locations, interrogation methods are demonstrated that can identify genetically distinct material from matched climatic conditions to predict optimal selections of parental germplasm for breeding material suited to different locations and future climates.

Keywords: underutilised crops, productivity, crop models, climate change

The Influence of Shifting Planting Date on Cereal Grains Production under the Projected Climate Change

Dae-jun Kim et al.

Poster position: A11

Dae-jun Kim[1], Jae-hwan Roh[2], Jung-gon Kim[3], Jin I. Yun[1]
[1] Department of Ecological Engineering, Kyung Hee University, Yongin 446-701, Korea
[2] Rice Research Division, National Institute of Crop Science, Iksan 570-080, Korea
[3] Korean Wheat & Barley Industry Development Institute, Suwon 441-857, Korea

Yield reduction in major cereal grains seems unavoidable with the existing cropping systems under the projected climate change in Korea. Crop models were used to predict the effects of planting date shift on grain yields of rice, winter barley and soybeans at 64 agroclimatic zones in Korea. The shift of planting date by 7, 14, and 21 days before and after the recommended planting dates were incorporated in DSSAT experiment files to simulate growth, development and grain yields of major cereal crops. These included 3 rice cultivars representing early-, medium- and late- maturity groups, 1 winter barley and 1 soybean cultivars. Partial mitigation in yield reduction was found with earlier planting in the early maturing rice cultivar and with delayed planting in the late maturing rice cultivar under the RCP8.5 projected climate change in Korea. Additional yield increase in winter barley was expected by earlier planting treatments. Soybean showed a positive effect on grain yield with earlier planting. However, the rate was much lower than the case with winter barley and delayed planting caused yield reduction.

Modeling crop yields and yield gaps in Russia, Ukraine and Kazakhstan under climate change

Friedrich Koch et al.

Poster position: B9

Friedrich Koch[1,2]*, Florian Schierhorn[1]*, Alexander Prishchepov[1], Daniel Müller[1,3]
[1] Leibniz Institute of Agricultural Development in Central and Eastern Europe (IAMO) Theodor-Lieser-Str. 2, 06120 Halle (Saale), Germany
[2] Helmholtz Centre for Environmental Research (UFZ), Permoserstraße 15, 04318 Leipzig/Germany
[3] Department of Geography, Humboldt-Universität zu Berlin Unter den Linden 6, 10099 Berlin, Germany
* Corresponding author (koch@iamo.de)

Global demand for agricultural products is projected to increase considerably. To satisfy the growing demand at low environmental costs is a key challenge for humanity. Russia, Ukraine, Kazakhstan can potentially contribute substantial additional production to global agricultural markets with their ample land reserves, fertile soils and high crop yield gaps. However, no comprehensive assessment of yield gaps in the region has been conducted to date. Of particular interest herein is the southern black soil (Chernozem) belt that possesses the highest production potentials in the region but is marred with frequently occurring droughts that are projected to increase further in terms of frequency and severity. The climatic conditions are in part also responsible for the prevailing low-input land management practices and low crop yields. We applied the process model SWAT to assess yield gaps throughout the region. SWAT includes plant growth and hydrology modules that are essential for large-scale physiological modeling in regions with volatile precipitation conditions because they allow to assessing climate, plant, soil and nutrient dynamics and simulating water management strategies. Our SWAT results for European Russia indicate yield gaps of 46-68% for spring and winter wheat, suggesting that land-use intensification, irrigation and re-cultivation of abandoned lands can potentially contribute to substantial production increases. We will further present how we will assess the impact of climate change on crop yields at different spatial scales and which options exist to reduce yield gaps and to better adapt agricultural management practices.

Modelling Efforts and Integrated Regional Studies in FACCE MACSUR

Martin Köchy

Poster position: D10

Martin Köchy[1]
[1] Thünen Institute of Market Analysis, Bundesallee 50, 38116 Braunschweig, Germany

MACSUR is a knowledge hub (first phase 2012-2015) that gathers the excellence of research in livestock, crop, farm and trade modelling in Europe. It will illustrate for political decision makers how climate variability will affect regional farming systems and food production in the near and far future (till 2050). Furthermore, it will assess the associated risks and opportunities for European food security.

MACSUR develops multi-faceted approaches for integrated assessments in diverse regions like Europe. Aspects of heterogeneity include environment, structure, policy, climate, soils. An ensemble of crop and livestock models is benchmarked, inter-compared and coupled to both climatic and economic models in collaboration with AgMIP. In addition, MACSUR assesses options for crop rotations, mitigation measures, adaptation measures across scales, and considers national and farm economics.

Scaling, uncertainty analyses, and probabilistic assessment of impacts using calibrated models complement AgMIP activities.

In MACSUR regional pilot studies we assess crop production, livestock management, and farm economics in an integrated way, developing RAPs for Europe and involving stakeholders. First results compatible with AgMIP global scenarios will be presented at project meeting in April 2014.

Development and application of a weather data client for preparation of weather input files to a crop model

Chung-Kuen Lee et al.

Poster position: D1

Chung-Kuen Lee[1], Junhwan Kim[1], Kwang Soo Kim[2]
[1] National Institute of Crop Science, RDA, Suwon 441-857, Korea
[2] Department of Plant Science, Seoul National University, Seoul 151-742, Korea

Crop yield prediction has been made using a crop growth model that relies on four categories of input data including soil, crop, management, and weather. Most crop models are a single column model, which requires individual weather inputs for each site of interest. The objectives of this study were to develop a weather data service client that generates weather input files for a crop growth model and to examine its application to yield prediction at a national scale. The weather data service client was designed and implemented to download daily weather data from the web-based weather data service portal operated by Korean Meteorological Administration (KMA) and to generate weather input files for the ORYZA 2000 model. In total, 4950 input files were generated to predict rice yield in 2011 and 2012 using the weather data service client. To generate nearly 5000 weather input files, it would take more than a month for a skilled person to download weather data from the KMA database and to reorganize those data to the input data format for the ORYZA 2000 model manually. Using the weather data service clients, several hours were enough to generate all of the input files without error associated with manual preparation as well as with minimum effort and labor.

AgMIP Rice Team Activities

Tao Li et al.

Poster position: C6

Tao Li[1,‡], Toshihiro Hasegawa[2*,‡], Xinyou Yin[3*,‡], Yan Zhu[4,‡], Kenneth Boote[5,‡], Myriam Adam[6], Simone Bregaglio[7], Samuel Buis[8], Roberto Confalonieri[7], Tamon Fumoto[2], Donald Gaydon[9], Manuel Marcaida III[1], Hiroshi Nakagawa[10], Philippe Oriol[6], Alex C. Ruane[11], Françoise Ruget[8,12], Balwinder Singh[1], Upendra Singh[13], Liang Tang[4], Fulu Tao[14], Paul Wilkens[13], Yubin Yang[15], Hiroe Yoshida[10], Zhao Zhang[16], Bas Bouman[1,†]

[1] International Rice Research Institute, Los Baños, Philippines
[2] National Institute for Agro-Environmental Sciences, Japan
[3] Centre for Crop Systems Analysis, Wageningen University, the Netherlands
[4] National Engineering and Technology Center for Information Agriculture, Nanjing Agricultural University, China
[5] University of Florida, USA
[6] CIRAD, UMR AGAP, France
[7] University of Milan, Italy
[8] INRA, UMR1114 EMMAH, F-84914 Avignon, France
[9] CSIRO Ecosystem Sciences, Australia
[10] National Agriculture and Food Research Organization, Japan
[11] NASA Goddard Institute for Space Studies, New York, USA
[12] UAPV, UMR1114 EMMAH, F-84914 Avignon, France
[13] International Fertilizer Development Institute, Florence, Alabama, USA
[14] Chinese Academy of Sciences, Institute of Geographical Sciences and Natural Resources Research, China
[15] Texas A&M University, USA
[16] State Key Laboratory of Earth Surface Processes and Resource Ecology, Beijing Normal University, Beijing 100875, China
[*] Corresponding: thase@affrc.go.jp; Xinyou.Yin@wur.nl
[†] The leader of AgMIP Rice Team
[‡] Members of leading group of AgMIP Rice Team. All other authors made equivalent contributions and are in alphabetical order by surnames.

AgMIP Rice Team was initiated under the umbrella of AgMIP at the kick of workshop at Bejing in 2011. It has thirteen crop modeling groups from Australia, China, France, Italy, Japan, Netherlands, CGIAR-IRRI and USA. The first annual meeting was held in December 2012 in International Rice Research Institute to share the achievements of the first-year implementation and to plan the activities for the next step. The second annual meeting will be held in Japan on 2 to 5 December 2013.

Over the last year, the team mainly focuses on the improvement of models for predicting rice response to CO_2 fertilization. We evaluated 12 rice crop models against multi-year FACE (Free-Air CO_2 Enrichment) experiments at two sites. Model simulation was implemented in two steps: 'blind' simulation, and simulation after model improvement or calibration. Groups in the team used own approaches to improve their model responses. The average responses and average predictions of all models on total above-ground biomass and grain yield were comparable or slightly improved before and after the model modifications. The differences between FACE measurements and predicting average of all models were less than 10% of measurements for both phases of simulation. However, some models might have uncertainty up to 20% of measurements. This exercise proved that current rice models are good enough for evaluating the

effects of CO_2 elevation on rice growth and yield if ensemble model approach is used for the evaluation.

Progress on the Maize Pilot Study

J.I. Lizaso et al.

Poster position: C5

J.I. Lizaso[1], J.L. Duran[2], K.J. Boote[3], S. Bassu[4], N. Brisson[#4], J.W. Jones[5], C. Rosenzweig[6], A. Ruane[6], M. Adam[7], C. Baron[8], B. Basso[9], C. Biernath[10], H. Boogaard[11], S. Conijn[12], M. Corbeels[13], D. Deryng[14], G. De Sanctis[15], S. Gayler[16], P. Grassini[17], J. Hatfield[18], S. Hoek[11], C. Izaurralde[19], R. Jongschaap[12], A. Kemanian[20], C. Kersebaum[21], N.S. Kumar[22], D. Makowski[4], C. Müller[23], C. Nendel[21], E. Priesack[10], M.V. Pravia[20], S-H. Kim[24], F. Sau[1], I. Shcherbak[9], F. Tao[25], E. Teixeira[26], D. Timlin[27], K. Waha[23], T. Tollenaar[28], S. Kumudini[28]

[1] Dep. Producción Vegetal, Fitotecnia, Technical University of Madrid, 28040 Madrid, Spain.
[2] Unité d'Agronomie, INRA-AgroParisTech, BP 01, 78850 Thiverval-Grignon, France.
[3] Dep. of Agronomy, P.O. Box 110500, Univ. of Florida, Gainesville, FL 32611.
[4] Unité de Recherche Pluridisciplinaire sur la Prairie et les Plantes Fourragères, INRA, BP 80006, 86600 Lusignan, France.
[5] Dep. of Agric. & Biol. Engr., P.O. Box 110570, Univ. of Florida, Gainesville, FL 32611.
[6] NASA Goddard Institute for Space Studies, Climate Impacts Group, 2880 Broadway, New York, NY 10025.
[7] CIRAD, UMR AGAP/PAM, Av. Agropolis, Montpellier, France.
[8] CIRAD, UMR TETIS, 500 rue J-F. Breton, Montpellier, F-34093.
[9] Dep. of Geological Sciences, Michigan State University, USA and Dept. Crop Systems, Forestry and Environ. Sciences, University of Basilicata, Italy.
[10] Helmholtz Zentrum München, Institut für Bodenökologie, Ingolstädter Landstraße 1, D-85764 Neuherberg.
[11] Centre for Geo-Information, Alterra, P.O. Box 47, 6700AA Wageningen, The Netherlands.
[12] WUR-Plant Research International, Wageningen University and Research Centre, P.O. Box 16, 6700AA Wageningen, the Netherlands.
[13] CIRAD-Annual Cropping Systems, C/O Embrapa-Cerrados Km 18, BR 020 - Rodovia Brasília/Fortaleza, CP 08223, CEP 73310-970, Planaltina, DF Brazil.
[14] Tyndall Centre for Climate Change research and School of Environmental Sciences, University of East Anglia, Norwich, NR4 7TJ, UK.
[15] Unité AGROCLIM, INRA, Domaine st Paul Site Agroparc, 84914 Avignon cedex 9, France.
[16] Water & Earth System Science (WESS) Competence Cluster, c/o University of Tübingen, 72074 Tübingen.
[17] Dep. of Agronomy and Horticulture, University of Nebraska-Lincoln, 178 Keim Hall-East Campus, Lincoln, NE 68503-0915.
[18] USDA-ARS National Soil Tilth Laboratory for Agriculture and the Environment, 2110 University Boulevard, Ames, IA 50011.
[19] Pacific Northwest National Laboratory and University of Maryland, 5825 University Research Court, Suite 3500 College Park, MD 20740.
[20] Department of Plant Science, The Pennsylvania State University, 247 Agricultural Sciences and Industries Building, University Park, PA 16802.
[21] Inst. of Landscape Systems Analysis, ZALF, Leibniz-Centre for Agricultural Landscape Research, Eberswalder Str. 84, D-15374 Muencheberg, Germany.
[22] Centre for Environment Science and Climate Resilient Agriculture, Indian Agricultural Research Institute, New Delhi, 110012, India.
[23] Potsdam Institute for Climate Impact Research, Telegraphenberg A 31, P.O. Box 60 12 03, D-14412 Potsdam.
[24] School of Environmental and Forest Sciences, University of Washington, Seattle, WA, USA 98195-4115.
[25] Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, 100101, China.
[26] Sustainable Production, The New Zealand Institute for Plant & Food Research Limited, Lincoln, Canterbury, New Zealand.
[27] USDA/ARS, Crop Systems and Global Change Laboratory, 10300 Baltimore avenue, BLDG 001 BARC-WEST, Beltsville, MD, 20705-2350.
[28] Monsanto Company

[#] N. Brisson passed away during the study in 2011.

Within the AgMIP Track 1 approach, we report the progress obtained by the Maize Pilot Team. Twenty three maize simulation models were included in the first study. Four sentinel sites, representing important zones of maize production, provided one-year site specific measurements for model simulations: Lusignan, France (43.3º N), Ames, Iowa, USA (42ºN), Rio Verde, Brazil (17.5º S), and Morogoro, Tanzania (6.5º S). For each site, 30-year of historical daily weather data were provided. Baseline weather was modified by changing maximum and minimum temperatures and [CO_2] levels. Simulations of baseline and modified weather in single factor series and in several combinations were obtained. Modelers were supplied sequentially with two levels of input information, low (only soil, phenology, and management), and high (initial conditions and time series of soil and crop measurements). In spite of simulated yield variability, the model ensemble accurately captured actual yields even with low information. Ensembles of 8-10 models would reduce substantially yield variability. Temperature increase had much larger and consistent response than CO_2 elevation in simulated yields. Higher temperatures also shortened life cycle of current cultivars, with small variability. Raising CO_2 levels resulted in higher yields and reduced crop transpiration, with largest variability at the highest simulated [CO_2]. The maize team has also been developing an improved maize model under the leadership of M. Tollenaar, from Monsanto. The new public maize model, AgMaize, will incorporate the best available algorithms simulating crop phenology, leaf area, photosynthesis, respiration, C partitioning, and N dynamics, and will have a modular structure adaptable to several modeling systems.

An Integrated Assessment of Climate Change Impact on Crop Production in the Nioro du Rip Basin of Senegal I: Crop Modelling

D.S. MacCarthy et al.

Poster position: B3

D.S. MacCarthy[1], M. Diancoumba[1], B.S. Freduah[1], S.G.K. Adiku[1], A. Agali[2], I. Hathie[3], J. Lizaso[4], D. Fatondji[5], M. Adams[6], L. Tigana[7], E. Koomson[1], P.C.S. Traore[5], S. Traore[2], J. Amikuzuno[8], J.B. Naab[9], D.Z. Diarra[10], B. Sarr[2], O. N'diaye[11], M. Sanon[7]

[1] University of Ghana
[2] AGHRYMET, Niger: Centre National d'Agro-Hydro-Météorologie du Niger
[3] IPAR, Senegal:Initiative Prospective Agricole et Rurale
[4] Technical University of Madrid, Spain
[5] ICRISAT Mali : International Crops Research Institute for the Semi-Arid Tropics
[6] CIRAD : Centre de Coopération Internationale en Recherche Agronomique pour le Développement
[7] INERA, B. Faso : Institut de l'Environnement et de Recherches Agricoles
[8] UDS, Ghana : University of development studies
[9] SARI, Ghana: Savanna Agricultural Research Institute
[10] METEO Mali
[11] ACACIM, Senegal :Agence Nationale de l'Aviation Civile et de la Météorologie

The economy of West Africa is highly dependent on agriculture which contributes between 40 to 60 % to gross domestic product and is home to about 300 million people. Crop production is largely dependent on natural weather which is increasingly becoming erratic. Projected climate change shows an increasing temperature trend and possibly a decline in rainfall, posing a major threat to agriculture productivity in the sub-region. This study aimed at assessing the future productivity of the major crops in Nioro, using two crop models and projected future climate data from five General Circulation Models (GCMs). DSSAT and APSIM models were calibrated with experimental data and validated with data collected from 220 farms in a socio-economic survey. With the aid of the QUADUI, which is an innovative desktop utility, the effect of climate change with and without adaptation on the yields of millet, maize and peanut were simulated for 220 farms using multi-year baseline (1980-2009) and mid-century future (2040-2069) climate projections of five GCMs namely: E (CCSM4), I (GFDL-ESM2M), K (Had GEM2-ES), O (MIROC5) and R (MPI-ESM-MR).The yields of millet were negatively impacted by climate change using both crop models (i.e. 22 to 46% and 7 to 22% for DSSAT and APSIM, respectively). Similarly, simulated yields of peanut were lower with all GCM projected climates compared with baseline simulated yields. For maize, the responses of the GCMs were varied with GCMs R and K giving the lowest simulated yields. Introducing adaptation strategies however reduced the negative impact of climate change on simulated yields. This study indicates that the projected future climate will adversely affect crop production in Nioro. The negative effects can, however, be minimized with the use of improved crop ideotypes.

Modeling insect pest distribution under climate change scenarios

A. Maiorano et al.

Poster position: A15

A. Maiorano[1], I. Cerrani[2], D. Fumagalli[2], M. Donatelli[3]
[1] DISAFA, Università di Torino, Torino, Italy
[2] JRC IES, European Commission, Ispra (VA), Italy
[3] CRA-CIN, Consiglio per la Ricerca e Sperimentazione in Agricoltura, Bologna, Italy

This work describes potential impacts of climate change on a maize insect pest and a novel approach for predicting its distribution based on known physiological responses to specific weather factors. The model is based primarily on developmental responses, as these determine climates under which an insect can achieve a stable, adaptive seasonality. Cold tolerance during wintering was also modeled through an original approach based on the concept of lethal dose exposure. We simulated the potential winter survival, distribution, and phenological development of the corn borer *Sesamia nonagrioides* at three time horizons (2000, 2030, 2050), using the A1B IPCC scenario. Two modeling solutions for the simulation of winter survival were compared: the first using air temperature only as weather input (AirMS); the second taking into account the fraction of larvae overwintering in the soil, therefore considering also soil temperature (SoilAirMS). The survival model was linked to a phenological model. The SoilAirMS approach showed the best agreement, compared to the AirMS approach. Nevertheless the AirMS approach allowed identifying areas where the agronomic practices suggested for controlling *S. nonagrioides* should be considered ineffective. The projections to 2030 and 2050 suggested an overall slight increase of more suitable conditions for the *S. nonagrioides* in almost all the areas where it develops under the baseline. In these areas *S. nonagrioides* could become a new insect pest with a potential strong impact on maize. Differently from other works based on too simplistic approaches, results suggested that a warmer climate does not necessarily increases insect pest risks.

Modelling soil borne fungal pathogens of arable crops under climate change

L.M. Manici et al.

Poster position: A16

L.M. Manici[1], S. Bregaglio[2], D. Fumagalli[3], M. Donatelli[1]
[1] Dep. of Agricultural and Environmental Sciences - Production, Landscape, Agroenergy, University of Milan, Milan, Italy
[2] CRA-CIN, Consiglio per la Ricerca e sperimentazione in Agricoltura, Bologna, Italy
[3] JRC IES, European Commission, Ispra (VA), Italy

Soil-borne fungal plant pathogens, agents of crown and root rot, are seldom considered in studies on climate change and agriculture due both to the complexity of the soil system and to incomplete knowledge of their response to environmental drivers. A controlled chamber set of experiments was carried out to quantify the response of six soil-borne fungi to temperature, and a species-generic model to simulate their response was developed. The model was linked to a soil temperature model inclusive of components able to simulate soil water content also as resulting from crop water uptake. Pathogen relative growth was simulated over Europe using the IPCC A1B emission scenario derived from the Hadley-CM3 global climate model. Climate scenarios of soil temperature in 2020 and 2030 were compared to the baseline centred on the year 2000. The general trend of the response of soil-borne pathogens shows increasing growth in the coldest areas of Europe; however, a larger rate of increase is shown from 2020 to 2030 compared to 2000 to 2020. Projections of pathogens of winter cereals indicate a marked increase of growth rate in the soils of Northern European and Baltic states. Fungal pathogens of spring sowing crops show unchanged conditions for their growth in soils of the Mediterranean countries, whereas an increase of suitable conditions was estimated for the areals of Central Europe which represent the coldest limit areas where the host crops are currently grown. Differences across fungal species are shown, indicating that crop-specific analyses should be run.

Assessing the effects of climate change on current smallholder-subsistence maize production in Southern Africa

Patricia Masikati et al.

Poster position: B16

Patricia Masikati[1], Sabine Homann-Kee Tui[1], Katrien Descheemaeker[2], Olivier Crespo[3], Andre van Rooyen[1]

[1] International Crops Research Institute for the Semi-Arid Tropics (ICRISAT, www.icrisat.org), PO Box 776, Bulawayo, Zimbabwe

[2] Wageningen University, Plant Production Systems Group, Wageningen, The Netherlands

[3] University of Cape Town, Climate Systems Analysis Group (CSAG), Cape Town, South Africa

Smallholder farming systems constitute the majority of farmers in Southern African and major cereal production has been declining and if not stagnated in the last 2 decades while on the other hand demographics are on the increase leaving most people food insecure and malnourished**.** The precarious food shortage in the region is due to a combination of factors that include unfavorable climatic conditions, poor and depleted soils; environmental degradation; failed sectorial and micro-economic policies among others. Climate superimposed on the multitude of structural problems in the different countries in southern Africa where people are un prepared or have inadequate adaptation strategies climate change can easily set back possible developmental gains by affecting sectors such as agriculture, water resources and infrastructure among others. We have limited knowledge on the interactions between increase CO2 temperatures and precipitation variations and their combined effects on plant and animal development hence adding to uncertainties surrounding future crop and livestock production in mixed farming systems of southern Africa. We used two crop models (APSIM and DSSAT) to assess the impact of climate change on maize production in southern Africa. Results showed possible reduction of maize grain and stover yields and also that days to physiological maturity will be substantially reduced. Simulated effects were at varying levels across the countries due to biophysical and socio-economic issues. Country climate outlook (connected to crop modeling) is necessary in southern Africa where most countries are net importers of food. This would assist governments to prepare for suitable crop varieties and markets and also to prepare for food imports in time.

Critical temperature and sensitivity for white immature rice kernels

Yuji Masutomi et al.

Poster position: A12

Yuji Masutomi[1], Makoto Arakawa[2], Toyotaka Minoda[2], Tetsushi Yonekura[1], Tomohide Shimada[1]
[1] Center for Environmental Science in Saitama, 914 Kamitanadare, Kazo, Saitama 347-0115, Japan
[2] Institute for Paddy Rice Research, Agriculture and Forestry Research Center, 1372 Kubojima, Kumagaya, Saitama 360-0831, Japan

The incidence of white immature rice kernels (WIRKs) due to high temperatures during a ripening period has been recently a problem in the rice production of Japan. What is worse, future global warming will increase the incidence of WIRKs. The objective of the study is to quantify the critical temperature at which WIRKs begin to emerge (T_{cr}), and the sensitivity of the incidence to temperatures during a ripening period (S_t). This information would be helpful for estimating the incidence of WIRKs under current and future global warming conditions. In this study, we focus on a variety of rice "Sai-no-kagayaki," which is a rice variety bred in Saitama prefecture of Japan. In 2010, extreme high temperatures in summer caused the high incidence of WIRKs for the variety.

To quantify T_{cr} and S_t, we first propose a simple statistical model that includes T_{cr} and S_t as parameters. Then T_{cr} and S_t for each WIRK type are statistically quantified by experimental fields data. The results showed that T_{cr}s for milky-white and white-core kernels (MAC) and basal-white kernels (BSL) were about 25 degree, while T_{cr} for back- and belly-white kernels (BAB) was about 27 degree. Thus we found that MAC and BSL begin to emerge at a lower temperature than BAB. S_ts for BAB and BSL were about 10 %/degree, while S_t for MLK was about 2.5%/degree. Thus we found that BAB and BSL have a higher sensitivity to temperatures than MLK. These results suggest that we should pay the most attention to BSL, which has a low critical temperature and a high sensitivity to temperatures.

The Coordinated Climate-Crop Modeling Project (C3MP): Overview and Protocol Evaluation

Sonali McDermid et al.

Poster position: D3

Sonali McDermid[1], Alex Ruane[1], Nicholas Hudson[2], Cynthia Rosenzweig[1,2], and more than 60 C3MP Participants

[1] NASA Goddard Institute for Space Studies, New York, NY, USA
[2] Columbia Center for Climate Systems Research, New York, NY, USA

This poster will present an overview of the Coordinated Climate-Crop Modeling Project (C3MP), and an initial evaluation of C3MP protocols and results. C3MP is an on-going initiative that has already mobilized over 150 crop modelers from over 40 countries in a coordinated climate impacts assessment via the Agricultural Model Intercomparison and Improvement Project (AgMIP). Crop modelers are invited to run a set of common climate sensitivity experiments at sites where their models are already calibrated, and then submit their results to enable coordinated analyses for high-impact publications and data products. Of particular interest is the sensitivity of regional agricultural production to changes in carbon dioxide concentrations, temperature and precipitation (CTW), which in many cases is more robust across crop models and locations than are the absolute yields. By coordinating an investigation into these fundamental sensitivities, C3MP enables an investigation of projected climate impacts across a range of global climate models, regional downscaling approaches, and crop model configurations. Initial results submitted to C3MP have been compiled and the C3MP protocols and methodology has been evaluated. The C3MP emulation of yield responses to CTW changes has proved a close fit to simulated crop yields in most contributed locations. We show that the C3MP emulators display a plausible range of crop responses to changes in CTW, and we demonstrate the utility of these response surfaces when evaluating the impact of climate change conditions. As more crop modelers conduct these experiments, coverage will increase in crops, models, farming systems, and locations to enable additional analyses of uncertainty in the agricultural impacts of climate change. By analyzing CTW sensitivities with today's climate as the origin, C3MP results will also facilitate the identification of key vulnerabilities and urgent interventions.

Integrated assessment of climate change and policy impacts on food security: a case study for protein crop supplies in Austria

Hermine Mitter et al.

Poster position: B14

Hermine Mitter[1], Franz Sinabell[2], Erwin Schmid[1]
[1] University of Natural Resources and Life Sciences Vienna, Institute for Sustainable Economic Development; Doctoral School of Sustainable Development
[2] Austrian Institute of Economic Research; franz.sinabell@wifo.ac.at

We present a methodology of how to use existing crop models with widely available economic data sets and established statistics in order to measure the impacts of climate change and policy adjustments on agricultural production systems and food security. Our case study is on a country in Europe but the method is transferable to other regions, policy scenarios and projections of climate change.

Approximately 75% of feed protein for livestock production in the EU is imported. During the last decade, European protein crop production has even diminished which raises concerns about supplies of protein in Europe. The recent reform of the Common Agricultural Policy (CAP) increases the competitiveness of protein crop production as farmers will be allowed to use cropland for producing legumes that would otherwise have to be set aside. We analyze two questions: (i) what is the likely impact of this policy change on supplies and land use, and (ii) how will climate change affect the competitiveness of protein crop production relative to other crops? We use Austria as case study, because it represents several European countries well-suited for protein crop production (the Danube basin).

We apply an integrated modeling framework to assess climate change impacts on level and variability of Austrian crop yields in combination with a policy reform, to analyze changes in national supply balances, land use, and to quantify economic and environmental effects of more intensive crop production. The bio-physical process model EPIC (Environmental Policy Integrated Climate) is applied to simulate, spatially explicit, annual crop yields and environmental outcomes for a historical period (1975-2005) and three climate change scenarios until 2040. Marginal opportunity costs of expanding protein crop production are estimated by the economic bottom-up land use optimization model for Austria BiomAT. The implications for crop supplies are quantified by using agricultural supply balances in a comparative static analysis.

Our results show that expected climate change and the policy reform are likely to raise domestic outputs of protein crops and the use of nitrogen fertilizer will decline.

Assessing Climate Change Impact on Rice Based Farming Systems in Sri Lanka and Adaptation Strategies using DSSAT and APSIM Models

S.P. Nissanka et al.

Poster position: B12

S.P. Nissanka[1], A.S. Karunaratne[2], W.M.W. Weerakoon[3], R. Herath[3], P. Delpitiya[3], B.V.R. Punyawardena[3], L. Zubair[4] and J. Gunaratna[5]
[1] University of Peradeniya
[2] University of Sabaragamuwa
[3] Department of Agriculture
[4] Foundation for Environment, Climate and Technology of Sri Lanka
[5] University of Rajarata

In line with AgMIP's attempts to develop adaptation to climate change for agricultural sector globally and regionally, the AgMIP-Sri Lanka project investigated the climate change impacts on rice based farming systems and adaptation strategies, led by the Stakeholder Institutes of Department of Agriculture and Agricultural Universities.

Commonly cultivated rice varieties (Bg300, Bg358, Bg357) of a major rice growing region (Kurunegala) selected for the study, where rice production and other socio-economic information of farm families are available, were calibrated for both DSSAT and APSIM models using experimental data obtained from the Rice Research and Development Institute. Rice yield was simulated for 104 farmer fields for two growing seasons (major and minor) for the base years (2012-2013), historical period (1980-2010), and mid-century (2040-2069) for five GCMs (CCSM4, GFDL-ESM2M, HadGEM2-ES, MIROC5, MPI-ESM-MR) of RCP-8.5 scenario. TOA-MD analysis was carried out using RAP strategies.

The base year RMSE for both seasons range around 1200-1300 kg/ha for observed (major-season 4289kg/ha; minor-season 3883kg/ha) vs simulated using DSSAT (major-season 4888kg/ha; minor-season 4410kg/ha). Compared to historical period, a significant yield reduction of 14%, 12%, 22%, 12%, 17% for the major-season and 31%, 30%, 42%, 28%, 35% minor-season, for the above five GCMs, was observed respectively. Among the adaptation strategies explored (adjusting planting window and short-duration variety), use of short-duration variety (Bg300) recovered yield losses significantly, especially in the minor-season where rainfall is relatively less and warmer. Similar trends were observed for APSIM model outputs as well. TOA-MD analyses revealed that the percentage losers are 68-70 and poverty level increase from 17% to 30% due to climate change.

Key words: Rice production, climate change impacts, food security, adaptation

Multi-model simulations for rice yield forecasts in Jiangsu (China)

V. Pagani et al.

Poster position: C13

V. Pagani[1], C. Francone[1], Z. Wang[2], S. Bregaglio[1], M. Donatelli[3], D. Fumagalli[4], F. Ramos[4], S. Niemeyer[4], Q. Dong[5], R. Confalonieri[1]
[1] Dep. of Agricultural and Environmental Sciences - Production, Landscape, Agroenergy, University of Milan, Milan, Italy
[2] Jiangsu Academy of Agricultural Sciences, People's Republic of China, Nanjing, Jiangsu, China
[3] CRA-CIN, Consiglio per la Ricerca e Sperimentazione in Agricoltura, Bologna, Italy
[4] JRC IES, European Commission, Ispra (VA), Italy
[5] Flemish Institute for Technological Research (VITO), Mol, Belgium

The Bio-physical Model Applications platform (BioMA) provides the opportunity to run multi-model simulations of crop growth and development against a common spatial database. Different crop models are characterized by their specific approaches to reproduce key physiological processes, thus producing varying crop responses to different environmental and climatic conditions. Within the EU-FP7 project E-AGRI on technology transfer of crop monitoring systems to developing economies the three crop models WARM, CropSyst and WOFOST were used to simulate rice growth in the Jiangsu province, China, in a warm (2006) and a cold (1999) season, using ECMWF weather data at 25 × 25 km resolution. The models performed similarly at field level with parameter sets calibrated on data of nine sites and two seasons. However, differing results of the crop growth simulations were obtained at the province level. While CropSyst-simulated biomass was driven mostly by air temperature gradients in the province, biomass simulated with WARM was dominated by radiation, with a more realistic response – especially in the warmest season – when air temperatures were higher than the optimum for the crop. WOFOST responded most strongly to high air temperatures, because unlike WARM it explicitly simulates the air temperature effect on respiration through a net-photosynthesis approach. Facilitated through the BioMA platform the multi-model approach allowed for detecting and assessing the crop models' different peculiarities especially under anomalous and extreme weather conditions.

Integrated Assessment of Climate Change Impacts on Principle Crops and Farm Household Income in Southern India

Paramasivam Ponnusamy

Poster position: B13

Paramasivam Ponnusamy, Geethalakshmi Vellingiri, Lakshmanan Arunachalam,Sonali Mcdermid, Raji Reddy Danda, Dakshina Murthy, Mahendran Kandaswamy and Sunandini Prema

This study aims to assess the impact of climate change on agricultural production in southern India and its implications for farm household income and food security. Farm households in Tamil Nadu, Andhra Pradesh, and other Provinces excluding south-western Kerala of the Deccan Plateau are located in the rain-shadow of the Western Ghats. With meagre annual rainfall averaging 500 to 900 mm, the region is experiencing steadily decreasing soil fertility, growing dependence on groundwater for irrigation, falling ground water tables, and increasing fallow lands - characteristics that may be impacted by changes in long term climate trends. Agriculture sustains over half of the region's population. The study is carried out in Tamil Nadu (TN) and Andhra Pradesh (AP) States of South India. Household production systems in the region are characterized based on sources of irrigation in the region. Irrigated rice based cropping system in TN and both rain fed and irrigated maize based cropping systems in TN and AP are taken up for integrated impact assessment.

Crop models DSSAT and APSIM with climate parameter inputs from select RCP based (RCP 4.5 and 8.5) scenario downscales and management inputs from farm surveys are used to simulate base and climate impacted future yields with/without adaptations. Simulated yields are used for economic analysis to assess impacts on household incomes, employment and poverty. Following Shared Socio-economic Pathways (SSPs) under varying developmental assumptions, we attempt to develop Representative Agricultural Pathways (RAPs) to assess future trends and values for regional level management inputs through a participatory discussion process. Some of these RAPs based management variables are used in crop models along with future climate parameters to simulate future yields. Future farm characterizations derived from RAPs are combined with crop model simulated yields in economic tradeoff analysis using a Multi-Dimensional (TOA-MD) model for overall household impact assessment. The integrated analyses are replicated for a set of adaptation options to assess their efficacy in moderating climate change impacts on the rice and maize crops based production systems and households of the study region.

A biome-based analysis of current and future global crop yields

T.A.M. Pugh et al.

Poster position: D14

T.A.M. Pugh[1], S. Olin[2], A. Arneth[1]
[1] Karlsruhe Institute of Technology, Institute of Meteorology and Climate Research (IMK-IFU), 82467 Garmisch-Partenkirchen, Germany
[2] Department of Physical Geography and Ecosystem Science, Lund University, Sölvegatan 12, S-22362 Lund, Sweden

Natural terrestrial vegetation occurs as part of functioning ecosystems whose composition and behaviour is dictated by the prevailing climatic conditions and other environmental factors, such as nutrient availability. Globally ecosystems can be broadly categorised into types, or biomes, according to the prevailing conditions and the dominant vegetation types therein. Throughout history humans have modified their surrounding environment, clearing natural ecosystems to provide raw materials and/or make space for other land uses, predominant among which is agriculture. These actions in themselves create new ecosystems which, excepting anthropogenic actions such as fertilisation and irrigation, will function under largely the same environmental boundary conditions as the ecosystems they replace. These boundary conditions thus define the potential for how efficiently a new land-use can provide the service it was created for, such as food production. Using global observations of actual and potential yield we consider the yields of the major global staple crops wheat, maize and rice as a function of the natural biome in which they are grown. We compare the observed yields with those generated by a process-based global crop model, LPJ-GUESS. We then extend these biome-based yields into the future and consider how management processes such as irrigation and cultivar adaptation may influence the results. Finally we contrast the yield for each biome area with the carbon storage potential of the natural vegetation within that biome under present and future conditions and consider synergies and trade-offs between these two important ecosystem services.

Agricultural processes can substantially affect global climate forcing from CO_2

T.A.M. Pugh et al.

Poster position: D15

T.A.M. Pugh[1], S. Olin[2], A. Arneth[1]
[1] Karlsruhe Institute of Technology, Institute of Meteorology and Climate Research (IMK-IFU), 82467 Garmisch-Partenkirchen, Germany
[2] Department of Physical Geography and Ecosystem Science, Lund University, Sölvegatan 12, S-22362 Lund, Sweden

Anthropogenic land-use and land-cover change has substantially altered fluxes of carbon between the terrestrial biosphere and the atmosphere, exerting a strong influence on global climate. Yet only relatively recently have anthropogenic land-use and -cover change been explicitly and widely represented in global terrestrial biosphere and Earth-System Models (ESMs). Typically such models represent all crops and pasture land (~35% of global land area in 2000) as grasslands. However, crops and pasture typically differ from natural ecosystems in terms of plant species, productivity, phenology, management, the annual growth cycle, and harvest; fundamentally affecting the amount of carbon stored by the terrestrial biosphere. We show that incorporating agriculture-specific processes in a global terrestrial biosphere model (LPJ-GUESS) can dramatically increase the carbon emissions resulting from land-use change by as much as 80% over period 1850-2005. Using climate forcing from an ensemble of ESMs we calculate the difference in terrestrial carbon accumulation over the period 1850-2100 under both moderate and extreme future climate pathways. We find that agriculture-driven differences in terrestrial carbon accumulation can result in a change in sign of the influence of the terrestrial carbon cycle on global climate from a net cooling to a net warming and influence global radiative forcing by as much as 0.5 W m^{-2}.

Projecting spring wheat yield changes on the Canadian Prairies: Resolutions of a regional climate model

Budong Qian et al.

Poster position: B7

Budong Qian[1], Ted Huffman[1], Hong Wang[2], Yong He[2], Jiangui Liu[1], Reinder De Jong[1]
[1] Eastern Cereal and Oilseed Research Centre, Agriculture and Agri-Food Canada, Ottawa, Ontario
[2] Semiarid Prairie Agricultural Research Centre, Agriculture and Agri-Food Canada, Swift Current, Saskatchewan

In addition to the uncertainty associated with crop models, climate scenarios are still a major source of uncertainty in projecting crop yield changes under climate change. Regional climate models (RCMs) are used as a tool for dynamic downscaling of climate scenarios from global climate models (GCMs) to regional scales for climate change impact studies. It is known that running an RCM is more expensive and time consuming at a higher resolution than at a lower resolution. Therefore, it is interesting to investigate how resolutions of an RCM might result in differences in the projected crop yield changes. We employed the CERES-Wheat model in DSSAT to simulate yield changes of spring wheat at 13 locations across the Canadian Prairies, with climate scenarios from a Canadian Regional Climate Model (CanRCM4) driven by a Canadian Earth System Model (CanESM2) with forcing scenarios RCP4.5 and RCP8.5 at 25km and 50km resolutions. Bias correction and a stochastic weather generator referred to as AAFC-WG were used to develop future climate scenarios as input to the crop model. The results showed that when changes were averaged across the locations, whether 25km or 50km resolution CanRCM4 data were used, the projected yield changes were fairly consistent, with approximately a 20% increase under RCP4.5 and close to a 30% increase under RCP8.5, especially if AAFC-WG was used to develop climate scenarios. Spatial distributions of the projected yield changes were also similar for the two resolutions of CanRCM4.

Agricultural impacts of climate variability and change in Eastern Africa

K.P.C. Rao et al.

Poster position: B10

K.P.C. Rao[1], G. Sridhar[1], Mary Kilavi[2], Richard Mulwa[3], Siza Tumbo[4], Moses Tenywa[5], Araya Alemie Berhe[6] and Benson Wafula[7]
[1] International Crops Research Institute for the Semi-Arid Tropics, Addis Ababa, Ethiopia
[2] Kenya Meteorological Department, Nairobi, Kenya
[3] University of Nairobi, Nairobi, Kenya
[4] Sokoine University of Agriculture, Morogoro, Tanzania
[5] Mekerere Univeristy, Kampala, Uganda
[6] Mekelle University, Mekelle, Ethiopia
[7] Kenya Agricultural Research Institute, Embu, Kenya

Climate change impacts on smallholder agriculture was assessed in four Eastern African countries - Kenya, Ethiopia, Tanzania and Uganda – using the protocols and tools developed by Agricultural Model Inter-comparison and Improvement Project (AgMIP). In each country, a study area of the size of a district (about 150-200,000 ha) representing at least three major agro-ecological zones of the country and having about 50,000 households was selected. Household surveys were conducted to obtain the required input data for crop and economic models. In Kenya, the assessment covered five different agro-ecologies in Embu County. Projected future climate change scenarios for mid (2041-2070) and end (2071-2100) century were downscaled to four weather stations. Coarse outputs of 20 CMIP 5 General Circulation Models (GCMs) for Representative Concentration Pathways (RCP) 4.5 and 8.5 were downscaled by delta method to generate location specific future climate projections. Experimental data from maize grown under different nitrogen regimes for both long and short rain seasons were used to parameterize and evaluate crop simulation models DSSAT and APSIM. Maize yields of main food crop Maize under observed and future climates were simulated with APSIM and DSSAT crop models that were calibrated to simulate the locally relevant varieties and management practices. The diversity in the management employed by the farmers in the target region was captured by setting up runs for each of the 441 farmers involved in the survey. Analysis of bias-corrected and spatially downscaled scenarios indicated substantial changes in the climatic conditions at all locations. All GCMs predicted higher increase in minimum temperature compared to maximum temperature and most GCMs projected rainfall amounts are increasing from 10 to 150% in the region. Couple of GCMs projected reduction in rainfall amounts by 20%. Both APSIM and DSSAT predicted an increase in Maize yields in four out of the five agro-ecologies with projected climatic conditions mainly due to an increase in rainfall and projected temperature changes were within the crop optimum range. Within the agro-ecology, household-level impacts differed with management. High input systems (>35 kg of N/ha) were found to be more adversely affected compared to low input systems. The analysis helped in identifying a sub-set of management practices that enable smallholder to adapt and take advantage of the projected changes in climate.

Climate Impact Estimates on C3MP's Worldwide Network of Crop Modeling Sites

Alex Ruane et al.

Poster position: D4

Alex Ruane[1], Sonali McDermid[1], Nicholas Hudson[2], Cynthia Rosenzweig[1,2], and more than 60 C3MP Participants

[1] NASA Goddard Institute for Space Studies, New York, NY, USA
[2] Columbia Center for Climate Systems Research, New York, NY, USA

We present preliminary projections of climate impacts from a network of 904 crop modeling sites contributed to the AgMIP Coordinated Climate-Crop Modeling Project (C3MP). At each site sensitivity tests were run according to a common protocol, which enables the fitting of crop model emulators across a range of carbon dioxide, temperature, and water (CTW) changes. When driven by global climate model projections, these emulators estimate probabilistic climate impacts across all sites for a range of scenarios and time periods. Preliminary results suggest consistently declining yields for irrigated and rainfed maize, with results comparable to (but slightly more pessimistic than) projections from an ensemble of global gridded maize models. Soybean and rice yield changes are relatively small; however wheat yields are projected to increase as some models demonstrate a beneficial reaction to initial temperature increases. Differences between C3MP results and comparisons with results from other AgMIP initiatives merit further study, so we invite you to join us at this workshop and to participate in C3MP in the months ahead.

An integrated analysis on Austrian agriculture - climate change impacts and adaptation measures

Martin Schönhart et al.

Poster position: B8

Martin Schönhart, Hermine Mitter, Erwin Schmid, Georg Heinrich, Andreas Gobiet

An integrated modelling framework (IMF) has been developed and applied to analyse climate change impacts and cost-effective adaptation measures in Austrian agriculture. Climate change is depicted by four contrasting regional climate model (RCM) simulations until 2050 and supplemented with three adaptation and policy scenarios. The IMF couples the bio-physical process model EPIC and the bottom-up economic land use model PASMA at NUTS-3 level considering agri-environmental indicators. Impacts from four RCM simulations show increasing crop productivity on national average. Changes in average gross margins at national level range from 0% to +5% between the baseline and three scenarios until 2040. The impacts are more pronounced at regional scale and range between -5% and +7% among Austrian NUTS-3 regions between the baseline and the three scenarios until 2040. Adaptation measures such as winter cover crops, reduced tillage and irrigation are cost-effective in reducing yield losses, increasing revenues, or in improving environmental states under climate change. Future research should account for extreme weather events in order to analyse whether average productivity gains at the aggregated level suffice to cover costs from expected higher climate variability.

Reimplementation and reuse of the Canegro model: from sugarcane to giant reed

T. Stella et al.

Poster position: C12

T. Stella[1], C. Francone[1], S.S. Yamaç[1], E. Ceotto[2], R. Confalonieri[1]
[1] Dep. of Agricultural and Environmental Sciences - Production, Landscape, Agroenergy, University of Milan, Milan, Italy
[2] CRA-CIN, Consiglio per la Ricerca e sperimentazione in Agricoltura, Bologna, Italy

The software design of simulation models often prevents their reuse and extension, forcing third-parties interested in modifying an available model to rewrite it from the beginning. This removes resources for model improvement, for the development of new models, and for the extension of their application domains, leading to the proliferation of software implementing models sharing large part of the algorithms. Component-oriented paradigm allows to overcome these limitations, favouring model extension and improvement, better maintenance, and massive code reuse. This study presents the application of these principles to the reimplementation of the sugarcane model Canegro, which led to the definition of an extensible, framework-independent component following the BioMA architecture. The innovation consists in the granularity and transparency of the implementation, as well as in architectural features that encourage the model analysis and extension. Each biophysical process (e.g., photosynthesis) is formalized through independent basic units (e.g., for light interception, energy conversion into assimilates, respirations), which can be easily substituted by alternative approaches. The advantages of this re-implementation lie (i) in the possibility of diffuse contributions to model development due to the independence from specific framework, and (ii) in the ease of reuse and modification of the model algorithms made possible by the fine granularity. The latter is here demonstrated through the extension of the component for giant reed (*Arundo donax* L.) simulation, a promising energy crop which shares several morphological and physiological features with sugarcane.

Strengthening Simulation Approaches for Understanding, Protecting and Managing Climate Risks in Stress-prone Environments across the Central and Eastern Indo-Gangetic Basin

Nataraja Subash et al.

Poster position: B11

Nataraja Subash, Harbir Singh, Babooji Gangwar, Guillermo Baigorria, Anup Das, Rajendra Dorai, Abeed Hossain Chawdhury, Andrew McDonald, Balwinder Singh and Sandeep Sharma

Climate change impacts are increasingly visible in Indo-Gangetic Basin of South Asia with greater variability of the monsoon. Direct and indirect impacts on agricultural production and thereby the food security and livelihoods of many small and marginal farmers, particularly in the more stress-prone regions of the central and eastern Indo-Gangetic Basin consist of India, Bangladesh and Nepal. Linking climate, crop and economic modeling will provide an insight into the integrated assessment of impacts of projected climate change on agricultural productivity of the region. The preliminary results of one site, Meerut (29^0 4' N, 77^0 46' E, 237 m ASL), of the Upper Gangetic region of the IGP, India based on AgMIP methodology is explained in this poster. To capture the yield variability, 76 farms were surveyed in 2009-10 to capture the variability. Sugarcane-wheat and rice-wheat are the most predominant cropping system followed in this region. The important observed variability of farms are viz., wide variability in dates of sowing - 17th October to 3rd January, Date of Harvest – 10th April - 17th May, Five cultivars – PBW223, PBW243,WL502, PBW343, UP232, No. of irrigations – 3,4 & 5, variability in N, P and K applications. In this preliminary analysis, we have calibrated the DSSAT and APSIM model for wheat crop. All GCMs predicted higher monthly mean maximum and minimum temperatures during the mid-century period 2040-2069 under RCP8.5 compared to baseline (1980-2010). All the five targeted GCMs (CCSM4, GFDL-ESM2M, HadGEM2-ES, MIROC5, MPI-ESM-MR) predicted more or less same nature of projections. DSSAT simulated higher yields under projected climate change scenarios compared to APSIM. This may be due to difference in sensitivity of DSSAT and APSIM with changes in CO_2 and temperature. The mean and variability scenarios are not different compared to mean only scenarios. TOA-MD results predict higher percentage of gainers (58-61%) with DSSAT as compared to APSIM (44-50%) under five climate scenarios. Overall, Climate change situation, APSIM predicts losses (1-12%) but DSSAT shows gains (15-21%) in mean net farm returns.

Software frameworks for crop model development and multi-purpose application

A. Topaj et al.

Poster position: C9

A. Topaj[1], S. Medvedev[1], V. Yakushev[1], A. Komarov[2], V. Shanin[2], V.Denisov[3]
[1] Agrophysical Research Institute, Grazhdansky pr., 14, 195220, Saint-Petersburg, Russia
[2] Institute of Physicochemical and Biological Problems in Soil Sciences, Institutskaya str., 2, 142290, Pushchino, Russia
[3] Klaipeda University, Herkaus Manto str., 84, LT-92294, Klaipeda, Lithuania

Nowadays, there is an obvious need for multi-purpose applications of crop models and, therefore, the model as a software product should satisfy requirements of various groups of stakeholders. The requirements formulated should serve as a blueprint for the design and implementation of the crop modeling software. Main focus of the contribution is made on collaborative model development including model decomposition issues and implementation of generic frameworks for multi-variant model use. Three main objectives are defined by the authors for such kind of systems:

- *Multivariate simulation* – run-time environment allowing the multiple running of the model with different input data in a batch mode.
- *Unified shell* – generic user interface that allows running various models inside of a single application via standard forms and use cases.
- *Structural adaptation* – ability to assembly the current implementation of simulation algorithm from the set of alternative pre-designed modules without recompilation of whole model.

The contribution presents a coherent view on mentioned problems based on results that have been elaborated in several research institutions of Eastern Europe. It contains short historical review, current state and prospective ideas for improvement of modeling infrastructure suitable to perform multi-factor computer experiments with crop or forest simulation models. In particular, authors present the original products APEX (**A**utomation of **P**oly-variant **EX**periments) and DLES (**D**iscrete **L**attice **E**cosystem **S**imulator) and briefly compare them with analogous products and technologies (DSSAT, GUICS, CAPSIS, OpenMI).

Infrared Warming Affects Leaf Gas Exchange and Water Relations of Spring Wheat

G.W. Wall et al.

Poster position: A5

G.W. Wall[1], B.A. Kimball[1], J.W. White[1], and M.J. Ottman[2]
[1] USDA-ARS, Maricopa, Arizona
[2] University of Arizona, Tucson

Atmospheric CO_2 concentration is rising, which is predicted to induce global warming. Our objective was to characterize and quantify the ecophysiological response of spring wheat (*Triticum aestivum* L. cv. Yecora Rojo) and its microclimate to any potential concomitant rise in ambient temperatures associated with global change. A Temperature Free-Air Controlled Enhancement (T-FACE) apparatus with infrared heaters was employed to warm the canopy temperature of spring wheat by 1.5 and 3.0 $^{\circ}$C during the diurnal and nocturnal periods, respectively. The experimental design was a completely randomized Latin square (3x3) consisting of three ecosystem warming treatments (control, heated, reference) in three replicates over three planting dates (Mar., Sept., Dec.) during 2007 and 2008. Gas exchange properties and water relations of leaves as well as soil CO_2 efflux were measured. Compared with either the control or reference plots, in the heated plots, the uppermost sunlit leaf and those lower in the canopy had warmer leaf temperatures, higher net assimilation rates, and a decrease in internal water status - but they had comparable stomatal conductance and relative water content. The soil CO_2 efflux was greater in heated compared with reference plots. These results are useful for development and validation of temperature response functions in crop growth models that are being used to perform impact assessment on the sustainability of cereal grain crop production in a future high-CO_2 world.

AgMIP Water: Integrating Water Scarcity into Future Agricultural Assessments

Jonathan M. Winter et al.

Poster position: A8

Jonathan M. Winter[1], Alexander C. Ruane[2], Cynthia Rosenzweig[2]
[1] Dartmouth College
[2] NASA Goddard Institute for Space Studies

Agricultural productivity is strongly dependent on the availability of water, necessitating accurate projections of water resources, the allocation of water resources across competing sectors, and the effects of insufficient water resources on crops to assess the impacts of climate change on agricultural productivity.

This poster will detail AgMIP efforts at the interface of water and agriculture, including a pilot project that deploys a coupled hydrologic, water resources, and crop model over the Central Valley of California to explore the implications of future climate on irrigated agriculture; the recently held AgMIP - USDA Economic Research Service Water Workshop, which brought together over 35 leading scientists in climate, hydrology, water resources management, agronomy, and economics to develop strategies for improving the representation of water supply and demand in agricultural assessments; research in development; and opportunities to become involved in AgMIP Water.

New Drought Indices and Assessment in Drought Monitoring

Nana Yan and Bingfang Wu

Poster position: A7

Nana Yan[1], Bingfang Wu[1]
[1] Key Laboratory of Digital Earth Science, Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, Beijing, China

Due to spatial coverage, data availability and cost efficiency, this paper focused on studying the potential to apply the satellite product to monitor drought. First is Standard Precipitation Index (SPI), which is widely used around the world for research and operational applications on meteorological and agricultural drought monitoring and early warning. SPI was designed to be calculated for any location that has a long-term precipitation record. Therefore, the accuracy of monthly precipitation data of TRMM (the Tropical Rainfall Measurement Mission) 3B43, was firstly investigated through comparison with rainfall data of forty ground stations in Hai Basin from 1998 to 2010.A single parameterized correction equation was presented to calibrate the TRMM rainfall data to formulate the series rainfall dataset of 30 year from 1981 to 2010. It was found that 3-month SPI was the best to depict the meteorological drought, which agreed well with the statistical drought information from 2000 to 2004. Second is Temperature-modified Anomaly NDVI Index (TANDVI) was improved based on the fact that NDVI was more affected by the accumulated temperature than precipitation in spring in the south plain of Hai Basin. The results indicated that the change of crop phenology would be an important factor which can bring the error on assessing the drought.

Irrigation and Rain Fed Croplands Separated Methodology Based on Remote Sensing

Hongwei Zeng et al.

Poster position: A6

Hongwei Zeng[1, 2], Bingfang Wu[1, 2, *], Nana Yan[1, 2]
[1] Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, 100101, China
[2] Key Laboratory of Digital Earth Science, Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, 100101, China
[*] Corresponding: wubf@irsa.ac.cn

Irrigation croplands are the main water consumption of agricultural water resources, especially in arid and semi-arid basins. Due to lack of stabilized water supply, the yield of rain fed croplands tends to show large fluctuation than irrigation croplands in different year, such as wet season and drought period. Normalized Difference Vegetation Index (NDVI) and NPP could monitor effectively crop condition and estimate crop yield during crop growing season. Based on this hypothesis on yield fluctuation in different year, this work constructed NDVI and NPP time series of wet season and drought period, presented a threshold method to separate irrigated and rain fed croplands. Shijin irrigation district located at Plain of ZIYA River (PZYR) of Hai basin, winter wheat, maize, and cottons are the main crop types in this region. Due to rainfall deficit, during the winter wheat growing season (April to June); irrigation water supply is necessary for increasing crop yield. In order to estimate water supply stabilization and promote water resources management, this work used threshold of NDVI and NPP to illustrate the whole process on separating irrigation and rain fed croplands.

Key words: NDVI; NPP; Irrigation; Rain fed

The Impacts of Climate Change on Rice Farming Systems in North-Western Sri Lanka

L. Zubair et al.

Poster position: C15

L. Zubair, S.P. Nissanka, P. Agalawatte, S.C. Chandrasekera, C.M. Navaratne, J. Gunaratna, D.I. Herath, R.M. Herath, A. Karunaratne, B.R.V. Punyawardhene, W.M.W. Weerakoon, K.D.N. Weerasinghe, P. Wickramagamage, E. Wijekoon, Z. Yahiya

As a contribution to the AgMIP project, the impacts of climate on farming systems in the Kurunegala District in Sri Lanka were analyzed based on farmer surveys undertaken for the 2011 and 2012 seasons. Meteorological observations for 1980-2010 were subjected to quality checks and gap filling. These data were used to generate future climate scenarios for the farms using the 20 GCM's in the CMIP5 archive under the RCP8.5 scenario with further analysis restricted to 5 GCM's that are more skillful in the region. Calibration of DSSAT and APSIM crop modeling were undertaken with experimental observations in selected years in the two cultivation seasons. After further tuning, these crop models were used to simulate cultivation in the 2011 and 2012 seasons, the historical and mid-21st century periods. The climate projections shows a rise in maximum and minimum temperature for the future period by1.5 to 2.5 ^{o}C and a rise in rainfall by 1-3 mm/day for both seasons except for a drop in a couple of models. The DSSAT crop model simulations showed a drop in yield that ranged from 1.7% to 17% for the main season with a wider range of declines in the minor season. At two sites, the losses led to a slight increase in the fraction of farmers who were adversely affected while in other sites the analysis showed larger fractions were adversely affected. In the latter sites, the use of short-duration variety mitigated yield losses significantly. Work to refine methodologies and understand uncertainties is in progress.

Key words: Sri Lanka, Rice, CMIP5, DSSAT, APSIM, TOA-MD