AgMIP 5
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POSTER ABSTRACTS

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BARTELS, W.-L. AND SULLIVAN, A. – CULTIVATING ACTIONABLE SCIENCE: ENGAGING STAKEHOLDERS IN AGMIP RESEARCH

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The AgMIP project is developing rigorous scientific outputs potentially useful for national, regional and local decision makers in strategic climate-related adaptation planning. However, studies have shown that simply identifying a potential use, or hoping that information might be useful, is not enough to ensure uptake. Attention to process design, identification and early engagement of user audiences are needed to optimize meaningful interactions between scientists and decision makers and to build open communication channels for on-going feedback. Because the AgMIP project aims to run model simulations with users’ needs and frames of reference at the forefront, a Stakeholder Unit (SU) was created to guide the work of regional research teams (RRTs) in effective stakeholder engagement practice. The SU will collaborate closely with Stakeholder Liaisons (SLs), embedded within each RRT, to diagnose pathways that will move researchers from outputs (models) to outcomes (models informing strategic decisions). This poster presents selected results from an initial survey conducted with AGimp researchers (n=51) in November 2014 to encourage reflection on Phase I project achievements and prepare for engaging stakeholders in Phase II. Results provide regional profiles for each team and scientists’ perspectives on potential target audiences, current partnerships, and what constitutes effective stakeholder engagement. RRTs will utilize survey results as a foundation for reflection as they work to ensure regionally-relevant actionable science. Furthermore, data will serve as a monitoring baseline to subsequent surveys that will measure progress/change. Through a cross-regional Community of Practice (CoP) RRTs will continue to exchange experiences about stakeholder engagement and to document successes (and failures). Lessons learned will add to our understanding of the factors that shape stakeholders’ capacity and incentives to use the outputs of research.
AgGRID

MÜLLER, C. ET AL. - STATUS UPDATED FOR THE AGMIP GLOBAL GRIDDED CROP MODEL INTERCOMPARISON: ANALYSES AND PAPERS UNDERWAY AND PLANNED

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The AgMIP GRIDded crop modeling initiative (AgGRID) has been developing the protocols and data for the GGCMI project since 2013 and recently published the modeling protocols for the first phase of the project in Elliott et al 2015. In October 2014 AgGRID held a paper-writing workshop at NASA GISS to kick-off development on the first several planned papers for the AgMIP GGCMI, which are now underway. We summarize here the protocols and papers underway.
Pests and Diseases Decision Support Systems (PDSS) aim to predict when and where a particular pest or disease will occur and advise its integrated pest management (IPM). Most of all developed PDSS is based on assumption about the insects and/or pathogens interactions with the host and the environment. However, critical thresholds of meteorological parameters determinants for the occurrence, spread and intensification of pests and diseases have limited relevance to the field scale. The disease (D) or pest (P) risk is a function of crop traits, DP traits, environment, and also the management profile used by farmers. For this reason, the present study developed the SMARTBIO IPM SYSTEM® as a universal framework for the development of PDSS based on historical and real time big data analysis of crop traits, disease and/or pest traits, environment and management profiles. The system was developed to analyze, advise and recommend pest or disease control in each farm or management group using Microsoft Visual Studio 2012, Microsoft dotNet C# and Framework 4.0. The system database was developed to support the database management systems Microsoft SQL Server 2012 or Oracle10g. Maps from each farm containing the bounds and information of each farm plot are imported from Auto CAD MAP, shape files (*.shp) or image files. Then the maps are displayed to the users by an open source library SharpMap (Geospatial Application Framework). Mobiles apps were also developed for Android using Java, SQL Lite and C++ allowing automation in data collection, storage and sending from routine surveys. Its usability and algorithms were implemented and validated during seven years in a sugarcane area of 27 thousands hectares and recently in other two areas of 45,000 and 35,000 ha for the Borer-Rot Complex integrated management. Now, it is also been tested for Orange Rust and Brown Rust of sugarcane. Among other features, SMARTBIO IPM SYSTEM® can (1) receive inputs from web based forms, wireless data transmission and information from integrated databases; (2) define and clustering plots in management groups for each farm, city, or region; 3) identify the risk factors for the occurrence of a particular disease or pest; 4) predict, map and classify each plot, management group or farm according to their susceptibility to the occurrence of pest or disease by the SMARTBIO SCORES® (where) and favorability (when); 5) automates crop season planning and sizing of the integrated pest management activities; 6) recommend and schedule of pest and disease surveys and controls; and 7) generate real time graphics and table reporting epidemiology, recommendations, decisions and management activities related to the integrated pest management program. The SMARTBIO IPM System® is the first one considering multiple management factors in big data, yield losses, and economic models for any disease or pest and able to be incorporated into crop models. For this reason, SMARTBIO IPM System® is an interesting tool to implement our knowledge of how management technologies and climate
change will affect diseases and pests occurrence and consequently the yield performance at a
global and regional levels.

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RODERO, P. ET AL. - A PREDICTION MODEL FOR SCORING AGRICULTURAL AREAS ACCORDING TO THEIR “SUSCEPTIBILITY” TO PESTS AND/OR DISEASES ATTACKS BASED ON DATA MINING OF MULTIPLE CROP MANAGEMENT FACTORS

As pointed out by the Pests, Diseases, Weeds and Ozone Working Group Report at the AgMIP 4th Annual Global Workshop, although a lot of modeling has been developed in the past on insects and diseases, many of the models being developed and used today do not model the disease or insect dynamics. They model some indicator, such as heat units and leaf wetness duration accumulators, to schedule an insecticide or fungicide application to avoid economic damage to the crop being managed. However, critical thresholds of meteorological parameters determinants for the occurrence, spread and intensification of pests and diseases have limited relevance to the field conditions because they are at the point scale, for a crop growing on a homogeneous area of land. In order to bypass this problem, we developed a prediction model for scoring agricultural areas according to their “susceptibility” to pests and/or disease attacks which take in account the multiple crop management factors. Due to the disponibility of rich databases, the Borer-Rot Complex – BRC (*Diatraea saccharalis*-*Fusarium subglutinas*- *Colletotrichum falcatum*), one of the most important pest-disease of sugarcane, rice, maize and sorghum, was used as a model pathosystem. Historical and real time inputs of BRC incidence and/or severity and multiple crop management factors for 70,453 sugarcane plots, from 2007 to 2013, were data mined using univariate analysis of three sugar mill’s databases. Using $x^2$ tests (and Fisher’s where appropriate) as well as calculated (unadjusted) odds ratios (ORs) with 95% confidence intervals as confidence intervals (CIs). Management factors that were shown to be significant or marginally significant (p<0.30; purposeful selection) and their ORs were used to develop the risk scoring system for BRC (SMARTBIO SCORE BRC®). The resulting risk scoring system was then validated using the 2014 data for the three sugar mills databases. From 162 factors analyzed, 97 were proved to be risk factors for the occurrence of BRC, including status of cultivar, stage of harvest, use of organic fertilizers, fert-irrigation, soil type, production environment, etc. SMARTBIO SCORE BRC® applied to 11,863 sugarcane plots in 2014 predicted susceptibility level closely approximates (r>0.9) that Internal Infestation Index of *Diatraea saccharalis* (III) and volumetric Index of Damage (VID) caused by *Colletotrichum falcatum* and/or *Fusarium subglutinas* in 2014, independent of the sugar mill, even being from different areas of Paulo State. Thus, the SMARTBIO SCORES® can be used to allow AgSystems to make an informed decision on the appropriate phytosanitary measures for the BRC integrated management in a particular sugarcane farm or management group. Also, SMARTBIO SCORES® might be incorporated into models that intend to consider the multiple crop management factors in studies of climate change impacts on disease and pests attacks in a global and regional scale.
SSEKANDI, W. ET AL. - MODELLING THE USE OF COMMON BEAN (PHASEOLUS VULGARIS L.) TRADITIONAL VARIETIES AND THEIR MIXTURES WITH COMMERCIAL VARIETIES TO MANAGE BEAN FLY (OPHIOMYIA SPP.) INFESTATION IN UGANDA

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The bean fly (Ophiomyia spp.) is considered the most economically damaging and widely distributed field insect pest of common beans in Uganda. In spite of the utilization of existing management approaches against the pest, reported damage has remained high. In this study a popular resistant traditional variety and a popular susceptible commercial variety were selected and evaluated in pure and mixed stands. The incidence of bean fly infestation on both varieties in mixtures with different arrangements (complete random versus rows), and different proportions within each of the two arrangements was modelled by using general linear mixed models (GLMMs). The proportion of resistant varieties in a mixture and the arrangement type significantly decreases bean fly damage compared to pure stands, with the highest decrease in damage registered in the complete random mixture with at least 50% of resistant variety. Highest reduction in root damage, visible days after planting, was found in random mixtures with at least 50% of the resistant variety. Smallholder farmers in East Africa and elsewhere in the world have local preferences for growing bean varieties in genetic mixtures. These mixtures can be enhanced by the use of resistant varieties in the mixtures to reduce bean fly damage on susceptible popular varieties.

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Data and Tools

BENISTON, J. ET AL. - THE LAND POTENTIAL KNOWLEDGE SYSTEM: GENERATING SITE-SPECIFIC ESTIMATES OF LAND POTENTIAL PRODUCTIVITY AND DEGRADATION RISK USING A MOBILE APPLICATION AND CLOUD COMPUTING

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Globally, the productivity of smallholder cropping and grazing systems is constrained by soil properties and degradation processes. Soils are managed at the field scale, but soil maps are generally too coarse to provide accurate soil property values necessary to estimate productivity and erosion potential, and to support management recommendations. The Land Potential Knowledge System (LandPKS) is currently being developed to crowd source site-specific soil and landscape data as a means of generating localized estimates of productivity and degradation risk, and to deliver these estimates to users in near-real time. The system consists of a modular suite of mobile phone applications and cloud-based analytics. The mobile application guides users through a site characterization process that generates point level data on land cover, topography, and soil properties. The users’ inputs are used directly in the parameterization of the APEX model and, coupled with additional location specific values from regional datasets, provide site-specific simulations. The resulting predictions of crop/biomass yields and soil erosion are used to provide users with a comparison of potential productivity and degradation risk for their respective plot entries. The system is being piloted in 2014 in Kenya and Namibia, with an initial focus on drylands. This poster will describe the methods used, as well as challenges encountered, in using these tools to develop site-specific simulation models. For current information, please see www.landpotential.org.
KIM, K.S. ET AL. - APPLICATION OF COMPOSITE DATA TYPES TO THE CERES-RICE MODEL FOR FACILITATING DATA ASSIMILATION IN CROP GROWTH SIMULATION

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The Decision Support System for Agrotechnology Transfer (DSSAT) model has been used to simulate biophysical processes between soil, crop, and atmosphere. For example, the CERES-Rice model, which is one of the DSSAT sub models for rice, could be used to simulate crop growth as well as biogeochemical cycles, e.g., water and nitrogen cycles over paddy fields. Because the CERES-Rice model predicts growth of rice dynamically, the errors in state variables associated with crop growth could result in considerable errors in crop yield and biogeochemical cycles. To minimize such errors, data assimilation could be used incorporating measurements associated with crop growth or biogeochemical cycles, e.g., through remote sensing. The objective of this study was to apply composite data types to the CERES-Rice model for facilitating data assimilation. The CERES-Rice model was written in C++, which support the use of composite data types. The call structure of the model was reorganized to allow data assimilation. The use of C++ could eliminate uncertainty associated with the choice of Fortran compiler. In our study, struct data type, which is one of composite data type in C++, was used to group state variables of the CERES-RICE model including soil, land, weather, individual crop, and management, control of simulation, and other input values. The values of these state variables were stored in a member of struct data type, which allows update their values, e.g., leaf area index, from the outside of the module where the variables were used. In addition, the values of key state variables that have been reported to differ under different operating systems, e.g., Ubuntu, Fedora, and CentOS, were same irrespective of linux distribution when the C++ version of the CERES-Rice model was used. The CERES-Rice model written in C++ could be improved further to support OpenMI and different types of input data, e.g., binary weather data, which merits further studies. This work was carried out with the support of Cooperative Research Program for Agricultural Science and Technology Development (Project No. PJ 010115022015), Rural Development Administration, Republic of Korea.
Accurate estimates of soil moisture (SM) and crop yield from crop simulation models are important for managing water use, monitoring agricultural production, and assessing food security. Even though current crop growth models, such as the Decision Support System Agrotechnology Transfer (DSSAT), have been widely used, the estimates may diverge from the reality due to uncertainties in forcings and parameters, and accumulation of computational errors. Assimilation of remotely sensed observations are able to improve model estimates. For example, ESA Soil Moisture and Ocean Salinity (SMOS) mission provides SM product from passive microwave observation at 1.4 GHz at spatial resolution of 25-40 km every 2-3 days. The recently launched NASA Soil Moisture Active Passive mission (SMAP) will soon provide SM product at a spatial resolution of 9 km by synergistically combining active and passive (AP) microwave observations at 1.26 and 1.4 GHz, respectively, every 2-3 days. Active and passive observations provide complementary information for dynamic heterogeneous landscapes, where active observations are more sensitive to soil surface roughness and vegetation water content and structure; while passive observations are more sensitive to the SM. Thus, assimilating synchronous AP observations directly improves both estimates of SM and vegetation parameters. Although the AP observations are provided at a reasonable temporal frequency, their spatial resolutions are too coarse for the heterogeneous agricultural landcovers. Algorithms have been developed to downscale SM to finer scales at 1 km by using data-driven probabilistic relationships between the coarse-scale SM to auxiliary high resolution products. Furthermore, a novel algorithm was developed to downscale brightness temperature (TB), at scale of 40 km such as those from the SMOS and SMAP to a resolution meaningful for agricultural applications.

The goal of this study is to present current developments of downscaling and assimilation framework using remotely sensed microwave observations for the agricultural applications. The framework was implemented in a rain fed agricultural region of the Brazilian La Plata Basin in South America, where soybean is the primary crop. The results demonstrate improvements in SM and crop yield estimates. Moreover, the downscaling algorithm was implemented in northcentral Florida and the results indicate low errors in the downscaled estimates of SM and TB, even during dynamic land-cover and heterogeneous micro-meterological conditions. Following the similar methodology, an algorithm capable of downscaling radar backscattering coefficient ($\sigma_0$) is being developed. These studies show potential abilities of our proposed methodologies for improved estimates of SM and crop yield using the upcoming SMAP products and observations.
RIVINGTON, M. AND CAMMARANO, D. – AGRIMOD: THE AGRICULTURAL MODELLING KNOWLEDGE HUB WEBSITE

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The Agrimod ‘Agricultural Modelling Knowledge Hub’ is a new website service, funded by the Climate Change, Agriculture and Food Security Programme (CCAFS). The purpose of Agrimod is to serve as a central knowledge hub for information on agricultural modelling activities worldwide. This knowledge hub is the first of its kind, designed specifically to facilitate access to resources and information relevant to agricultural modelling. Agrimod will provide a lasting repository of details about models, data and case study applications. The vision is to unite the existing agricultural modelling community by providing a platform whereby models and their applications can be showcased, their improvement discussed and new collaborations built, and streamlining the process by which data sources are available and new modelling activities are developed.

The rationale for Agrimod is the recognition of the growing need, particularly in developing countries, to address national capabilities for researching agriculture and food security using modelling approaches. The additional pressures on agriculture come from many sources including climate change, growing populations, changing diets and behaviours and the need for sustainability. Agricultural research to address these issues includes the use of mathematical models and computer simulations to better understand how a particular agro-ecological systems and the people living within them may respond to any given environmental, management, economic or policy change. Agrimod aims to help develop integrated research across science disciplines byt aiding understanding of different modelling activities.

Agrimod is also intended to be a user–friendly information portal to people in other areas of research or new to agricultural modelling, looking to develop skills and acquire first-hand knowledge on agricultural modelling issues, applications and data sources. Agrimod aims to provide a facility that enables users to access the information, knowledge and data they need in order to more successfully develop and employ agricultural modelling to address key research issues.

The site is organised into two main features: creating content and taxonomy based search filters. Users first register to become content editors, then up-load content. The site is structured to represent models, case studies and data. The search functions enable users to find details about other models, their applications and find sources of data. The coverage includes: crops, livestock, economic and trade, farm and agricultural systems, soils, supporting information (i.e. sub-models, data tools etc.), software and modelling platforms. However, the aim is to have a very broad range of coverage to encompass any research activity related to modelling within agriculture.

The Agrimod development site is available at: www.agrimod.org This is the site to visit to register and start to up-load content. The site is still under development, the aim being to add further features over time to improve the sites utility. Messages regarding Agrimod can be sent to: agrimod@hutton.ac.uk
SHELIA, V. ET AL. - CRAFT - A NEW SOFTWARE FRAMEWORK FOR SPATIAL APPLICATIONS OF CROP MODELS AT A REGIONAL SCALE

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The CCAFS Regional Agricultural Forecasting Toolbox (CRAFT) is a user-friendly client application and database implementation for regional yield forecasting and climate change applications. It is designed to use spatial data schemes through the use of 5 arc minute and 30 arc minute resolution grids. Schematization at three different spatial scales at a country, state/province and district level are considered. For the crop simulation the gridded input data include weather and soil conditions, cultivar and other management levels that must be prepared using ArcGIS and then imported into the CRAFT database. CRAFT is integrated with external engines; one for crop modeling for spatial crop simulations and one for seasonal climate forecasts using the Climate Predictability Tool (CPT) developed by the International Research Institute for Climate and Society (IRI). This allows for the support of multi crop model capabilities using the harmonized data format (ACE) and crop model data translation tools that have been developed by the Agricultural Model Intercomparison and Improvement Project (AgMIP). In the current version the Cropping System Model (CSM) of DSSAT has been implemented, while APSIM and SARA-H are under development.

CRAFT simulates yield for each individual grid cell based on the predefined inputs and using statistical forecasting based on the seasonal predictors yields are adjusted. Through spatial aggregation and probabilistic analysis of the forecast uncertainty for both short-term and long-term periods, predicted yield can be determined for a region at different spatial resolutions. CRAFT includes options for hindcast analysis, de-trending and post-simulation calibration of model predictions from historic agricultural statistics. It supports risk analysis and climate change impact studies on crops as well. Analyses of the simulation results can be conducted through comparing different scenarios, reviewing the output statistics and visualization with thematic maps. Several case studies that have been conducted by CCAFS stakeholders for six Asian countries are promising.
Regional Integrated Assessments

AHMAD, A. ET AL. - VULNERABILITY OF WHEAT GROWERS TO CLIMATE CHANGE DURING 2040-69 IN RICE-WHEAT CROPPING ZONE OF PAKISTAN

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Wheat productivity, a prerequisite for food security is extremely vulnerable to climate change globally in general, and arid to semi-arid regions of Pakistan in particular. Climate change hazards would be more devastating in future because there would be 2.8 °C rise in maximum and 2.2 °C in minimum temperature for mid-century (2040-2069) in Rice-Wheat (RW) cropping system. The main thrust of this study is to develop adaptation strategies through crop growth models (DSSAT and APSIM) to combat the effects of climate change at farmers’ field and improve the livelihood of the farmers in the hotspot areas along with dissemination of relevant information to stakeholders. Crop growth models were calibrated and validated at experimental field data to develop the robust genetic coefficients. Calibrated models were validated at farmers’ field (155) data of five districts in RW cropping system, regarding all agronomic aspects of wheat management from planting to harvesting. A close agreement was recorded for farmer field wheat yield with simulated one. When models were validated at farmers’ field, goodness of model (R²) with values of 0.64 was recorded in DSSAT and 0.37 for APSIM between observed and simulated yield of 155 farms. Comparison of individual farmer yield showed that DSSAT simulated wheat yield with percent difference (PD) ranging from -25 to 17% and -26 to 40% having Root Mean Square Error (RMSE) 436 and 592 kg ha⁻¹ with d-statistic (0.87 and 0.88) and bias was observed 0.98 and 0.96 for DSSAT and APSIM, respectively. Climate change impact was quantified working with crop models for baseline climate (1981-2010) and future climate of five GCMs (CCSM4, GFDL, HadGEM, MIROC5, and MPI-ESM) for mid-century (2040-2069). Mean yield reduction for DSSAT ranged between 6.2 to 19% while for APSIM yield reduction was 10.6 to 12.3% with five GCMs. Adaptation technology was developed for wheat crop to cope with the ill effects of changing climate at farmer’s field. To achieve high productivity and meet the need of growing population, it would be required to increase the planting density and fertilizer use up to 30 and 25% respectively which was considered as one of the adaptation strategy for promising varieties with 50% greater potential. Due to high temperature the cropping seasons will be affected and 15 days earlier planting over current is recommended. These strategies have a significant impact in reducing the vulnerabilities of the changing climate with 22% improvement in wheat yield to sustain food security. If current production technology prevails in future, there would be about 62 to 73% losers and poverty rate would be between 36 to 42% due to disconcerted climate. Quantification of climate change impact on future
agricultural production systems depicted that there would be 49 to 67% losers and poverty rate would range between 18 to 23%. Potential adopters of the adaptation strategies ranged from 90 to 91% and poverty could reduce from 15 to 16% after the implementation of the adaptation strategies.
AHMAD, A. ET AL. - IMPACT OF CLIMATE CHANGE ON FINE RICE
PRODUCTIVITY AT FARMERS FIELD IN PAKISTAN

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Changing climate threatens the productivity of agriculture sector making it vulnerable both biophysically and economically. Pakistan’s economy is dependent upon agriculture and these climatic risks are major threats for sustainability of agricultural systems, which would be devastating not only for the socio-economic conditions of the rural household but also jeopardizing the food security.

DSSAT & APSIM Models were calibrated on experimental data and validated on collected 155 farmer’s field data from five districts of Punjab. Results of experimental and farmers’ farm data proved that performance of both models (DSSAT & APSIM) for rice was good. DSSAT simulated yield of 155 farms with $R^2$ (0.53), RMSE (409 kg ha⁻¹) and d-stat (0.80) while $R^2$ (0.44), RMSE (440 kg ha⁻¹) and d-stat (0.78) were calculated for APSIM. Due to changing climate, there is a reduction in rice yield differently with 30%, 20%, 13%, 7% and 6% (mean 15.2%) by DSSAT, and APSIM decreased yield 19%, 14%, 16%, 15% and 18% (mean 17.2%) using five GCMS GFDL, MPI-ESM, CCSM4, MICROC5 and Had-GEM respectively. If the current production system prevails in future, there would be about 69 to 82.6% losers for DSSAT and 72 to 76% losers in case of APSIM due to perturbed climate. Poverty rate in changing climate would be between 33 to 38% in DSSAT and from 35 to 37% in the case of APSIM. Quantification of climate change impact on future agricultural production systems depicted that there would be 57 to 70% losers in case of DSSAT and 60 to 71% losers for APSIM and poverty would be from 16.6 to 19% for DSSAT and 18 to 19.2% for APSIM. To achieve high productivity and meet the need of growing population, it would be imperative to increase the sowing density up to 15% for rice and fertilizer use up to 15% was considered as one of the adaptation strategy to make up the soil fertility status and high fertilizer requirement for new varieties.
AKUMAGA, U. AND TARHULE, A. - THE IMPACT OF CLIMATE CHANGE ON CROP YIELDS AND ADAPTATION OPTIONS IN THE NIGER RIVER BASIN, WEST AFRICA

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Climate change is estimated to substantially reduce crop yields by 50% in Sub-Saharan West Africa by 2050. Therefore, better quantification and understanding of the impact of climate change on crop yields is urgently needed. In this paper, we employed AquaCrop, a process-based model developed by the FAO, to quantify the risk of climate change on several key crops in the Niger Basin. AquaCrop was also used to explore the effects of various adaptation measures on crop yields. The crops analysed include cowpeas, maize, millet, and sorghum under rainfed cultivation systems in various agro-ecological zones within the Niger Basin. The adaptation strategies investigated include changes in the sowing dates, soil nutrient status, and soil management among others. The results of the model showed a very good agreement between the simulated and observed yields at each location, with $R^2$ values between 0.75 and 0.99. In addition, temperature increase led to decreased crop yields while precipitation increase led to improved crop yields. On average, temperature had a larger effect on crop yields so that the combined effects of a 2 °C increase in temperature and a +10% increase in precipitation could still be a net loss of crop yields by 25%. Crop yields were worse when temperatures increased and precipitation decreased. The results revealed that management factors such as soil fertility had a much larger effect on crop yield than the climatic change factors by a 4:1 margin in some cases. These results provide guidance on effective climate change adaptation strategies for rain fed agriculture.
ALAGARSWAMY, G. ET AL. - THE HIGHLY VARIABLE RESPONSE OF MAIZE YIELD TO CLIMATE CHANGE ACROSS EAST AFRICA

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With rising food demand and stagnant production, food insecurity is pervasive in sub-Saharan Africa. Maize yield in East and Southern Africa is inherently low due to imminent water shortage, limited use of improved cultivars, and little replacement of plant nutrients. Increasing climate variability and change may exacerbate this situation. Increasing yields of major crops through improved management and identifying strategies to improve resilience to climate change are critical goals.

Our objectives in this study are: (i) to assess the potential of nitrogen fertilizer to mitigate the impact of current climate variability and, (ii) to assess the impact of projected climate change on maize productivity across highly heterogeneous East Africa. We selected maize due to its importance as a major food crop and its sensitivity to climate and nitrogen limitations. Various climate datasets are linked to CERES Maize of DSSAT v.4.5 to examine the effect of climate on maize productivity, and the potential for management practices to reduce climate vulnerability. Point simulations using observed climate (1984 to 2011) are presented for Katumani, Kenya, and Choma and Kasama, Zambia. The effects of nitrogen fertilizer are analyzed to determine the potential to reduce vulnerability. To assess the impact of projected climate change, we conduct high resolution spatial modeling using WorldClim data to represent current climate and four GCMs to provide data on change between 2000 and 2050.

Analysis of impact of recent climate shows that coefficient of variation for yield ranges from 45% in a dry to 21% in a wet site. Yield response to nitrogen depends on precipitation amounts, season length and temperature. There is little response to nitrogen in hot, dry Katumani when precipitation is below 200 mm. The threshold of low response to nitrogen is 450 mm in cooler and wetter Choma. With warming temperatures, more of East Africa is expected to resemble the Katumani situation and experience declining response to nitrogen. In wettest site, Kasama, response to nitrogen varies little between years. Due to high leaching, split applications of nitrogen confer increased resilience to climate variability. The impact of projected climate change is examined across East Africa on a 0.05 x 0.05° spatial resolution. The results are shown as maps of current, future and changes in temperature, precipitation, length of growing season, water deficit and yield. Results indicate high spatial variability in how climate is projected to change, with some areas getting wetter and others drier, and highlands warming faster than elsewhere. The yield response is complex depending on initial climate and how it is expected to change. A few areas in the highlands and wetter zones are expected to see rising yields, but much of East Africa is expected to see declining yields as the length of the growing season declines and water deficits worsen. Crop management
recommendations are highly spatially specific, pointing to the importance of conducting spatially explicit analysis using dynamic and processed-based crop simulation models.
ANDREA, M.C.S. ET AL. - ECONOMIC AND ENERGY YIELD GAP ANALYSIS RELATIVE TO NITROGEN FERTILIZATION OF MAIZE IN BRAZIL

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In Brazil, average yields of main crops such as maize are less than potential, especially under rainfed conditions. Crop management must be improved in order to achieve higher yields and decrease the yield gaps. Nitrogen, a high-cost input in economic and energy terms, is the most common management decision to increase maize yields. Therefore N fertilization, usually done via mechanized operations, should be analyzed in order to determine the profitability of such management decisions under local conditions.

Two important locations (Diamantino and Jataí) for Brazilian maize production were assessed. For each site, data on climate, soil, crop management and historical regional yields were used to characterize the maize production system. With those data, a simulation approach was followed with the DSSAT CERES Maize model coupled with the CENTURY soil carbon module, to determine potential rainfed yields and yield response to N rates. With simulated yields, the yield gap for each location was determined. Mechanized N application was considered the only variable operation during the production cycle (sowing to harvest). All operations were accounted for in terms of economic and energy cost of the inputs (applied inputs, machinery and fuel). The economic and energy profitability of N management was made through the determination of cost and return based on the variation of the application rates of N. Simulated rainfed potential production averaged 7.6 and 6.5 t ha⁻¹ in Diamantino, and 8.5 and 8 t ha⁻¹ in Jataí, for both soils in both locations, respectively. The yield gap in those same conditions averaged 2.8 and 2.7 t ha⁻¹ in Diamantino, and 1.8 and 1.5 t ha⁻¹ in Jataí.

Simulated yields under nitrogen rates (0, 20, 40, 60, 80, 100, 120 and 140 kg N ha⁻¹) for both soils ranged from 1.7 to 9.0 t ha⁻¹ and 1.1 to 8.9 t ha⁻¹ in Diamantino, and from 1.9 to 10.3 t ha⁻¹ and 2.2 to 10.2 t ha⁻¹ in Jataí. Analyzing the economic profitability of production for each N rate scenario, the best scenarios in Diamantino were 60 and 120 kg N ha⁻¹ and the best scenario in Jataí was 80 kg N ha⁻¹, for both soils in each location. Between the worst and the best scenarios, the increase of economic returns in both soils averaged 140% in Diamantino and 117% in Jataí.

The energy profitability for both locations and soil was found to be higher at 60 kg N ha⁻¹. Between the worst and the best scenarios, the increase of energy return over investment (EROI), in both soils, averaged 39% in Diamantino, and 50% in Jataí. The decrease of grain embodied energy (EE), in both soils, averaged 80% in Diamantino and 88% in Jataí. Based on the simulated and the historical yields, Jataí presented more suitable conditions to achieve higher yields and more economically profitable scenarios with higher return per area.
than Diamantino. The results suggest that there are other factors interfering with achieving higher yields, since the average recommended urea rate for each location is similar to the most profitable simulated rates. Further study will include other locations across the country and more detailed characterization of an average maize production system, with respect to input use.
ANTLE, J. ET AL. - AGMIP’S TRANSDISCIPLINARY APPROACH TO REGIONAL INTEGRATED ASSESSMENT OF CLIMATE IMPACT, VULNERABILITY AND ADAPTATION OF AGRICULTURAL SYSTEMS IN AFRICA AND SOUTH ASIA

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This poster presents economic impact results (adoption/adaptation, production, income, poverty) from regional teams in Sub-Saharan Africa and South Asia that are part of the Agricultural Model Intercomparison and Improvement Project (AgMIP). All of the teams are utilizing the new integrated assessment methodology developed by AgMIP. This approach represents a departure from approaches in the literature in several dimensions. First, the approach is based on the analysis of agricultural systems (not individual crops) and is inherently trans-disciplinary: it is based on a deep collaboration among a team of climate scientists, agricultural scientists and economists to design and implement regional integrated assessments of agricultural systems. Second, in contrast to previous approaches that have imposed future climate on models based on current socio-economic conditions, this approach combines biophysical and economic models with a new type of pathway analysis (Representative Agricultural Pathways) to parameterize models consistent with a plausible future world in which climate change would be occurring. Third, adaptation packages for the agricultural systems in a region are designed by the research team with a level of detail that is useful to decision makers, such as research administrators and donors, who are making agricultural R&D investment decisions. Finally, the approach represents not only “mean” impact the distribution of impacts among farm populations. The poster summarizes the impact assessment and adaptation analysis results, comparing and contrasting among study areas, and highlighting the role of the Representative Agricultural Pathways in climate impact assessment.

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BELETSE, Y. ET AL. - IMPACT OF PROJECTED CLIMATE CHANGE SCENARIOS ON THE PRODUCTION OF POTATOES IN SOUTH AFRICA

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Potatoes are one of the most important non-grain crop world wide. In Sub-Saharan Africa, Egypt and Algeria produce about 4.5 M tons per year. South Africa is second largest potato producer in Southern Africa with an annual production of about 2.1 M tons from 51,000 ha. Potatoes are produced throughout the year in South Africa. The production areas have diverse climatic condition and farmers get substantial difference in yield. Crop models simulate temporal effects of multiple stresses on crop production; they can be a good representation of reality if they reproduce observed data with acceptable accuracy. Further crop models are also useful tools to assess impacts of climate change on crop production and explore adaption potential of crops. A study was carried out using DSSAT crop model to evaluate sensitivity of current potato production system to projected climate changes for a major potato production region in South Africa. DSSAT was calibrated using observed experimental data. Past potatoes productivity and yield variability was simulated for 90 farmers using historical weather data (1980-2009) at CO₂ of 360 ppm. Future potatoes productivity was simulated using CO₂ of 571 ppm for a period of 2040-2069 projected by 5 GCMs.

Projections of future climate changes for potato producing regions in South Africa showed an increase in temperature and variability in rainfall, increasing the risk of crop failure in some provinces and increase in yield in the other provinces. Over all South Africa potato production under current agricultural system is projected to increase by 7%. However, GCMs produced differences in yield across all regions, for example, in Limpopo yield losses of 28-33% was estimated whereas for the Western Cape yield increase of 7-11% was projected. Further analysis on the crop model simulations is necessary to understand why the crop model produced such different simulations of the same crop across the entire region.
DIETZEL, R. ET AL. - SEQUENTIAL MODEL ANALYSIS OF MIDWESTERN PRODUCTION SYSTEMS WITH APSIM

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**Purpose:** Cropping systems models are powerful tools to address combined agricultural targets that include increasing crop yields, maintenance of soil quality, and minimization of environmental risks. However, for the models to be able to appropriately address soil and environmental aspects and simulate yearly carry-over effects and feedback mechanisms, it is necessary to run in a sequential mode. Such a test increases the complexity of the simulation process. Here we ask whether the Agricultural Production Systems siMulator (APSIM) can accurately simulate crop and soil aspects of dominant Midwestern United States cropping systems in a sequential mode, so that it can be used as a tool to assist in the design of profitable and resilient production systems.

**Scope:** To calibrate and evaluate the performance of APSIM in simulating continuous corn with and without cover crops, and corn-soybean rotations for six continuous years in Iowa. Then to apply the model to estimate the optimum in-season precipitation regime for maximizing yields and minimizing water losses from the system.

**Methods:** For calibration we used high resolution datasets that include soil temperature, soil moisture, water flow in tile drainage, soil nitrate, soil CO$_2$ efflux, biomass, and crop yields. Several APSIM modules were configured for this project (version 7.5). For crops we used maize, soybean models, and the wheat model to approximate rye cover crop growth and development. The soilN model was used for organic carbon and nitrogen cycling. The surfaceOM model was used for residue decomposition, the SWIM model for soil water infiltration and movement, and the soilTemperature model for soil temperature. The model ran in a sequential mode to account for the carry-over effects of the previous crops including a spin up period of 10 years. The continuous corn treatments and corn-soybean rotation were used to calibrate the model and the soybean-corn rotation was used to test model performance.

**Results:** APSIM satisfactorily simulated soil temperature and water content, tile drainage, soil nitrate, soil CO$_2$ efflux, biomass, and grain yield for six consecutive years. The cover crop carry-over effect on corn yields was simulated well in some of the years. The critical level of the in-season precipitation for maximizing yields and minimizing water loss was around 425 mm.

**Conclusions:** We provided a comprehensive sequential calibration of APSIM for Midwestern US production systems and showed that the model can be used as a tool for soil quality assessments in addition to crop production aspects.

**Recommendations:** Sequential calibration is time consuming and particular attention is needed in the specification of the management practices. An error early in the simulation process will affect the performance of the subsequent years. Sequential model calibration will become very important and protocols and better calibration strategies need to be developed.

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DURAND, W. ET AL. - AGMIP, OPPORTUNITIES AND CHALLENGES OF A GLOBAL FRAMEWORK IN REGIONAL SOUTHERN AFRICA

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World population is expected to increase, particularly fast over the African continent. Increasing food production is thus vital in order to match the future food demand and work towards a self-sustained Africa.

The Agricultural Model Intercomparison and Improvement Project (AgMIP - www.agmip.org) is proposing an innovative integrated assessment of agricultural systems subject to future conditions. The project is designed to create interactions between future climate projections, crop models and socio-economic situations so as to provide more holistic impact assessment, and explore representative agricultural pathways for systems to adapt in the future. The global project supported 2 regional projects in southern Africa; one focusing on Botswana, Namibia, Lesotho, South Africa and Swaziland, and the other focusing on Malawi, Mozambique, South Africa and Zimbabwe.

We would like to present and discuss the AgMIP first phase achievements: a solid methodological framework and preliminary results, and giving special emphasise to challenges and opportunities that offer the AgMIP global initiative for regional southern Africa.

Southern Africa is predominantly a semi-arid region with high rainfall variability, characterized by frequent droughts and floods. The climate is highly seasonal with hot, wet summers and cool, dry winters (except for south western South Africa). The region is highly diverse in terms of cropping and socio-economic systems. The agricultural system is 'dual', with well-developed commercial farming systems on large farms, and subsistence-based production systems on small farms. The yields obtained by the traditional smallholder farmers are very small in comparison to the world's standards or the commercial farmer production levels in the region.

AgMIP framework provides a consistent approach to connect climates, crop models and socio-economic conditions, hence enabling national, regional and global impact assessments, comparisons and improvements. The best available historical records of 1980-2010 were gathered and used in combination with gridded data where needed. The future climate projections reflect 20 existing GCMs, 5 have been used in southern Africa at this stage. AgMIP has linked with 19 crop models (number varying depending on the crop considered), the DSSAT and APSIM crop models have been used at this stage. Maize and sugarcane were modelled in South Africa, mixed crop-livestock systems in Zimbabwe, and subsets of those in the other countries. The agricultural systems are simulated under different adaptation conditions in order to assess the independent and combined socio-economic impacts. At this stage 3 questions were addressed: (i) what is the sensitivity of current agricultural systems to climate change, (ii) what is the impact of future agricultural systems to climate change and (iii) what benefits adaptation could bring?
The project results concur with IPCC headlines and scale of changes. Temperatures over southern Africa are increasing with high confidence, while rainfall projections are uncertain. Despite progress made to face climate variability, those future conditions are expected to stress water availability. In lesser extent, the project revealed a potential delay in on-set of the rainy season, which could lead into shorter rainy season and further stress water availability. Appropriate measures exist and have a beneficial impact to mitigate and adapt agricultural systems to climate change stress. How to go now from those recommendations to finding the measures that are both applicable at small farms scale and steer sufficient governmental support?

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DURAND, W. ET AL. - LINKING SATELLITE IMAGERY, SURVEYING AND CROP MODELING TO ASSESS IMPACTS OF CLIMATE CHANGE ON MAIZE PRODUCTION AT DISTRICT LEVEL IN SOUTH AFRICA

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Although most dynamic crop models have been developed and tested for the scale of a homogeneous plot, applications related to climate change are often at broader spatial scales that can incorporate considerable heterogeneity. The approach followed in this study was to base crop model simulations on a field level maize crop mask that was developed using satellite imagery and crop type classification. The impact of projected climate change on maize production was assessed in three districts, Bloemfontein, Bethlehem and Bothaville in the Free State Province of South Africa using the DSSAT crop model. Crop management such as row spacing, plant population and planting dates were derived from objective yield surveys and associated with the fields proportionally to their occurrence. GIS and pedo-transfer functions were used to derive soil profile descriptions for each field based on land types. Fertilization was based on the yield potential of each field. Past (1980-2010) and future (5 GCMs for the time period 2040-2070, with RCP 8.5 and CO₂ of 571 ppm) maize productivity was simulated for each field. Field level simulations have the advantage that they can be summarized to different levels such as, quinary catchments or districts and can be presented in map or graph format.
DURAND, W. ET AL. - INTEGRATED ASSESSMENT OF IMPACTS OF PROJECTED CLIMATE CHANGE ON MAIZE PRODUCTION IN THE SOUTHERN AFRICA


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An impact of projected climate change on maize production was assessed in three Southern Africa countries, Namibia, Botswana, and Namibia, and South Africa using climate, crop and economic models. 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 CO2 of 571ppm) maize productivity was simulated. These results then were provided to the economist to characterize the economic impacts using the Trade of Analysis for multi-dimensional impact assessment model (TOA-MD). Projections of future changes in climate in Southern Africa showed an increase in temperature and variability in rainfall, increasing the risk of crop failure and food insecurity in the region. DSSAT and APSIM simulated 20% yield reduction if maize is managed with current practices into the future, causing an increase in poverty rates of 3%. When policy is adjusted to deal with future changes in climate simulated yield increased by 10% and poverty rates decreased.
KADIYALA, D.M. ET AL. - LINKING SATELLITE IMAGERY AND CROP MODELING FOR INTEGRATED ASSESSMENT OF CLIMATE CHANGE IMPACTS ON CHICKPEA YIELDS IN SOUTHERN INDIA

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Chickpea (Cicer arietinum L.) is the largest pulse crop grown in India and the second largest food legume in the world. It occupies around 15 per cent of total pulse area globally and is cultivated in almost 52 countries. Chickpea is a cool season food legume and exposure to high temperatures at reproductive stage may result in severe yield reduction. Heat stress at reproductive stage is becoming a major constraint to chickpea production because of large shift in chickpea area from the cooler, long season environments to warm, short-season environments. Increase in area under late sown conditions, reduction in winter period and anticipated temperature rise due to climate change are the major threats to chickpea production. Given the importance of chickpea as a major pulse crop, it is highly necessary to study and understand the impacts of future climate changes on chickpea productivity in major chickpea growing regions. In the present study, crop domain mapping was undertaken using high temporal remote sensing imagery in chickpea growing regions of Andhra Pradesh. The sequence analysis tool of DSSAT v4.5 was used to simulate fallow-chickpea rotation in the study regions to understand the impact of climate change using the climate projections from the Fifth Coupled Model Inter-comparison Project (CMIP5) and the Representative Concentration Pathways (RCP) for carbon emissions currently in use by the IPCC Fifth Assessment Report. The results indicate that as compared to baseline climate, the climate change by 2069 (Mid-century period) may decrease the yield of chickpea by 4.3 to 18.6% across various locations tested. In spite of projected increase in annual rainfall the reduction in yield under climate change in fallow-chickpea crop rotation is attributed to the rise in temperature. Yield benefits with various adaptation options revealed that advancing the sowing window by one fortnight and application of one critical irrigation at 60 DAS found to be beneficial in increasing chickpea yields under climate change.
KIM, C.G. ET AL. - IMPACTS OF CLIMATE CHANGE ON KOREA’S FOOD SUPPLY USING SIMULATION MODEL FOR CLIMATE-AGRICULTURE RELATIONS (SIMCAR)

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Purpose
Analyzing the impacts of climate change on food supply and suggesting proper counter-measures so as to ensure a stable food security in Korea.

Scope
The crop to be analyzed with regards to the impacts of climate change is rice, to which the crop growth model can be applied. As for the target year and period for predicting the climate change, the years up to 2100 are considered. However, for the purpose of the analysis of rice supply, the years 2030 and 2050 have been selected.

Methods Used
The Crop Estimation through Resources and Environment Synthesis (CERES)-Rice model and the agriculture simulation model (KASMO) were used to analyze the impact of climate change on food supply. The integrated model for analyzing the relationship between climate change and food supply, the Simulation Model for Climate-Agriculture Relations (SIMCAR) was developed using the CERES model and the KASMO.

Results
The rice unit yield analysis showed 7.6% increase by the baseline based on 2050, but 11.6% by RCP4.5 and 17.2% decrease by RCP8.5 in comparison on the average yield. While rice production was predicted to decrease by 32.7% by the baseline in 2050, it was 56.0% decrease by RCP4.5 scenario and 60.1% decrease by RCP8.5 in comparison with the average production. The climate change scenario relative to the baseline showed decrease in unit yields and area to show decrease of 60.1% (based on RCP8.5) in 2050 in comparison with the average yield to show a further decrease of 27.4% in comparison with the baseline. Rice production reduction lowers food supply to 50% and thus results in even more imports. This implies that food security can be worse due to climate change.

Conclusions
An important task is to find an answer about where Korea is currently positioned and what Korea should do. An in-depth review should be conducted about the possibility of buying food with funds any time in the future, and importing a large volume of food. In this context, the importance of food security is thus understandable in connection with climate change.
**Recommendations**

Stable supply of food adapted to climate change needs step-by-step positive actions to control national risks. In particular, it is necessary to enforce the following strategies in each field for the stable food supply system adapted to climate change. That is, analyze the impacts of climate change on food supply; develop and disseminate climate change adaptation technology; maximize the use of food production potential by using domestic natural resources; build a national food integration system in consideration of self supply and independent supply; practice smart agriculture by using convergence technology including IT·BT·NT; and build a risk management system to tackle the uncertainty of climate change.
KLEIN, T. ET AL. - SPATIAL EXTENSION OF HEAT AND DROUGHT STRESS IN EUROPEAN WHEAT PRODUCING AREAS

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There is growing evidence that, in many areas of the world, extreme heat is already limiting crop productivity. Also, climate change scenarios project increased extreme events frequency and/or intensity, implying that crop failure could become more recurrent already by the mid of the 21st century, with consequences for food security. In Europe, several studies have stressed the importance of extreme heat for wheat production. However, many of these assessments focus on particular areas and somehow fail to address the spatial dimension of the problem. Based on gridded climatic data for 1950-2013 issued from the ENSEMBLES EU-FP6 project (E-OBS), in this contribution we analyze the evolution of the European wheat production area under climatic stress. Specifically, we investigate to what extent wheat production areas have been affected in the recent past by either extreme heat or drought. Agro-climatic indices are used to infer the occurrence of adverse conditions, while the exceedance of specific thresholds is taken as a rule for the characterization of extreme years. The results indicate that since the 1970s, a growing share of European wheat production areas have been affected by either extreme heat or drought. The fraction of total areas with at least a 25% chance of experiencing adverse climatic conditions has increased from less than 0.2 in the 1970s to about 0.4 in the 2010s. This increase is most pronounced in Eastern and Central Europe and over the Iberian Peninsula. At the national scale, we found contrasting results, with a marked increase of the area affected by heat stress in many of key producing countries, including Spain, Germany, Poland and Ukraine, with no clear tendency in France. This work is a contribution to the EU-FP7 project MODEXTREME, whose overarching goal is to improving the capability of biophysical models to simulate vegetation responses to climatic variability and extremes.

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MACCARTHY, D.S. ET AL. - AN INTEGRATED ASSESSMENT OF CLIMATE CHANGE IMPACT ON CROP PRODUCTION IN THE NIORO DU RIP BASIN OF SENEGAL

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The economy of West Africa is highly dependent on agriculture, which contributes between 40 to 60% to gross domestic product. Crop production is largely dependent on natural weather, which is increasingly becoming erratic. Projected climate change therefore poses a major threat to the sub-region. This study is aimed at assessing the future productivity of the major crops in Nioro, using two crop models and five projected future climate data. 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 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 future (mid-Century) climate projections of five General Circulation Models (GCMs) namely E (CCSM4), I (GFDL-ESM2M), K (Had GEM2-ES), O (MIROC5) and R (MPI-ESM-MR). The TOA-MD model was then used to assess the impact of climate change with and without adaptation on farmers’ livelihood. Percentage increments in millet yield was observed in three GCMs ranging from 4% to 40% while percentage reductions were observed in two GCMs from 19% to 35% using DSSAT, and APSIM simulated yield reductions of between 9% to 23% across GCMs. With maize, yield reductions were simulated (DSSAT and APSIM) across GCMs compared with baseline simulated yields. For peanut, APSIM simulated yield increments while in DSSAT, except for one GCM, all others simulated yield reductions. Introducing adaptation strategies however reduced the negative impact of climate change on simulated yields. Consequently, farmers may witness varying levels of negative impacts in their net per farm revenues and per capita income, and increases in poverty rates under hypothesis of climate change without adaptation. Taking into account the RAPs, farmers may experience significant gains in their net revenues; per capita income and declines in poverty levels in the future even under climate change. When we account for adaptation, as well as future increases in agricultural development, most farmers may gain from climate change. 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.
MACCARTHY, D.S. ET AL. - ASSESSING THE SENSITIVITY OF MAIZE PRODUCTION ON SMALLHOLDER SYSTEMS TO PROJECTED CLIMATE CHANGE IN NIORO BASIN, SENEGAL

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The potential impact of climate change on future food security is increasingly becoming a subject of interest for research, particularly, in Sub-Saharan Africa. Smallholder farmers in this region are expected to be severely affected due to the over reliance on rain-fed agriculture. Hence the need to assess the potential impacts of projected climate change in order to plan for mitigation strategies to avert any adverse impact. This study therefore seeks to assess the sensitivity of maize production in Nioro du Rip basin, located in Senegal. The Agricultural Productions Systems sIMulator (APSIM) version 7.4 and Decision Support Systems for Agrotechnological Transfer (DSSAT) version 4.5 calibrated and evaluated for maize were used. The weather input data used in the crop simulation models were from 5 General Circulation Models (GCM-CCSM4_E, HadGEM2-ES_K, GFDL-ESM2M_I, MPI-ESM-MR_R and MIROC5_O) and a 30-year baseline historic weather data, together with soil data, farmers’ management practices and crop genetic information. Information on farmers management practices were obtained from a household survey conducted in 2007 in the region and used as input data for the model, as well as 45 kg N ha⁻¹ applied as an improved soil fertility management. Yield outcomes were analysed for significant differences between baseline yields and climate projections, among GCMs, soil type and soil fertility management options using ANOVA and Student t-test for mean separations. Both crop models simulated a general reduction in the yield of maize, though few reductions were not statistically significant. The extent of change varied between crop models, GCMs, soil types and soil fertility management. Maize yield was simulated by DSSAT to decrease by between 48 and 25% while APSIM simulated grain yield reductions was between 13 to 2%. The extent of the sensitivity of maize production to climate change is also expected to be influenced by soil management practices and soil types. The use of mineral fertilizer reduced the sensitivity of maize to climate change impact significantly and also reduced the variability in the yield of maize significantly. Differences in yield outcome between models can be attributed to difference in the types of input data required, and the difference in their sensitivity to weather parameters (temperature and CO₂). Maize production on smallholder systems in this region is sensitive to climate change as simulated by both models and the extent of sensitivity varied widely across GCMs, soil type and management practices used. The use of mineral fertilizer has the potential to reduce the sensitivity of maize production to climate change.
NISSANKA, S.P. ET AL. - CLIMATE CHANGE IMPACT ON FUTURE RICE YIELD IN A MAJOR RICE GROWING DISTRICT OF SRI LANKA

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Climate projections for Sri Lanka indicate a further warming trend and enhanced rainfall variability in the future making some areas even drier in the years to come. Estimates suggest that rice yield could be reduced by nearly 6% for a 0.5 °C temperature rise equating to a reduction in GDP of 0.2%. Unavailability of integrated analytical tool for assessing the climate change impact on future rice production and adaptations strategies have given rise to poor decision making with respect to crop management and socio economic aspects. Investigation of climate vulnerabilities of the rice farming systems will assist in developing policies to find adaptation strategies to meet future food security challenges. Therefore, the present study was initiated to analyze the impact of climate change by means of crop-climate modeling for rice farming systems in one of a major rice growing districts of Kurunegala in Sri Lanka.

Randomly selected 104 farmer survey data during 2012/2013 growing seasons (Minor and Major) were used to evaluate the effect of climate change on present and future rice farming systems. The DSSAT predicted yield performances of rice for baseline (1980-2010), downscaled 20 Global Climate Models (CMIP5-RCP8.5) in mid-century (2040-2069) and for climate sensitivities (AgMIP-C3MP) across three study sites (Rajanganaya, Nikaweratiya and Bathalogoda) in Kurunegala district were analyzed to synthesize decisions to queries and/or choices of genotypic and management suitability for present and future climates.

Yield simulation for rice farmers across all three locations and 20 different GCMs with the present crop management systems, indicated that yield reduction was almost double for the minor season where the rainfall is relatively less and slightly warmer compared to major seasons. Among the different GCMs, INXA, IAXA and IKXA were the worst impacted on rice farming in both seasons while IHXA and ILXA exhibited the lowest impact.

According to C3MP results, two rice cultivar (Bg 300 and Bg 357) reported diverse yield performances with diverse sensitivities to climate for Bathalogoda experimental sites. Overall major cultivation season reported that comparatively higher rice yields compared to minor season for the three sites across Kurunegala for the actually observed climate over baseline period. According to CMIP5-RCP 8.5 climate predictions for the study sites showed the yield drop of up to 20% in major season and it was up to 40% during minor growing season.
PARKER, P.S. ET AL. - USING A GENERATED WEATHER RASTER AND SOIL PROFILE MAP TO SIMULATE CROP MANAGEMENT AND YIELDS FOR THE 5 MAJOR CROPS THROUGHOUT A REGION IN SOUTHERN GERMANY

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The ability of bioeconomic simulation modelling to realistically predict agricultural adaptation is limited by the degree of detail in crucial model components. Model robustness must be tested before localized calibrations can be applied to regions of heterogenous environmental conditions.

FarmActor (Aurbacher et al., 2013) was used to simulate the timing of field management actions (planting, harvest etc.) and yields of winter wheat, barley and rapeseed, spring barley and silage maize as the predominant crops in a distinct region of Germany, by linking weather data and the crop growth simulation model EXPERT-N (Priesack, 2006). The integrated models were calibrated to observed experimental data (Wizemann et al., 2015) and phenological observations (German Weather Service, 2012) and then run from 1990 to 2009, forced with climate data from ERA-interim Reanalyses data which was downscaled with the Weather and Research Forecast (WRF) model to a 12 X 12 km² grid (Warrach-Sagi et al., 2013). Variability in regional soils was replicated with 10 different soil profiles mapped at 1/25,000 scale. The nature of the forcing climate data dictates temporal aggregation for analysis, so that validity is examined by comparing mean simulated planting and harvest dates and yields to official records in the area.

The mean predicted planting dates are very close to observations over the period, within a few days of observations, but show less variance. Harvest dates are accurately predicted as well, within one to two weeks, and the variances are closer to observations. Predicted winter wheat yields are well simulated in comparison to observed data, but maize yields are underestimated, while winter and spring barley and winter rapeseed yields are much greater than district yields. The degree of variance in simulated yields is acceptable in wheat, winter barley and maize, but excessive in spring barley and winter rapeseed. Cross-sectional examination of yields shows that the different soil profiles are responsible for more yield variance than simulated weather cells in all crops.
While the coupled models appear accurate in predicting crop management dates and physiological development, the inaccuracy in yields in all crops except winter wheat calls into question the reliability of the integrated models when applied, as is, outside of calibration conditions. That soil parameterization is responsible for more variance than generated weather is helpful in seeking to improve performance and encouraging in terms of the method of weather generation.

Reliable extension of the model to include all soils in an area together with artificial spatial climatic variability may require regionalized calibration to increase crop model stability.
**RAO, K.P.C. ET AL. - IMPACTS OF CLIMATE VARIABILITY AND CHANGE ON CROP PRODUCTION IN EASTERN AFRICA**

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Comprehensive assessment of climate change impacts on smallholder agricultural systems was carried out at selected locations representing diverse agro-ecological conditions in four Eastern Africa countries – Ethiopia, Kenya, Tanzania and Uganda. Using AgMIP protocols and tools, this assessment has quantified potential impacts of climate change on current and future agricultural production systems and benefits from adaptation. Trends in the observed climate data (1980-2010) for 16 study locations have shown a general increase in temperature of varying magnitude at all locations. On an average, the region is getting warmer by 0.02 °C every year. While no clear increasing or decreasing trend was observed in rainfall, an increase in year-to-year variability was observed at most locations. The predicted median increase in temperature varied between 3 and 5°C, while that in rainfall varied from 5 to 34%. In general the increase in temperature is low and rainfall is high at locations near equator. Impacts of climate variability and change on performance of maize varied from one agro-ecology to the other depending on the current rainfall and temperature regimes. The impacts varied from about +60% in Kenya to about -30% in Tanzania. The positive impacts are associated with current below optimal temperatures and projected increase in rainfall. By making simple adjustments to the current management practices such as change in variety, plant population and fertility management, smallholder farmers in Eastern Africa can adapt and even benefit from the projected changes in climate.
RASUL, F. ET AL. - AGMIP-PAKISTAN OUTREACH ACTIVITIES: FOSTERING THE STAKEHOLDERS ENGAGEMENT TO ADVOCATE RISKS AND ADAPTATIONS TO CHANGING CLIMATE

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Modern day food production is sternly obstructed by climate change which is an unassailable reality and has been frequently observed in Pakistan by recurring floods, drought, higher temperatures, glacial receding, erratic monsoon pattern which has proved to be an eye opener for legislators. Recent climatic problem solving techniques proved to be helpful for farmers to adopt in the changing climate if addressed in appropriate way can lead to sustainable development of climate resilient farmlands in developing countries. Integrated climate, crop and economic modelling techniques developed in recent times are providing solutions to farmers around the world through AgMIP global program involving its outreach activities. The AgMIP-Pakistan team took various initiatives of engaging farmers, policy makers, Agricultural and Agri-extension departments of Govt. of Pakistan, public and private companies in agribusiness, academia and researchers throughout the country and brought them at one platform to discuss their woes and worries related to vulnerabilities and vulgarities of climate change that they have faced or are under threat in one or the other way. About 800 participants registered with AgMIP Pakistan in 4 major events held during Phase-1. More than 15 media groups have given coverage to AgMIP-Pakistan’s events on TV and news articles. Recent floods, droughts and unpredictable monsoon rainfall and changing intensity of rainfall has played havoc with the farming communities and associated agrarian businesses. Integrated assessment to measure the risks and possible adaptive measures which may lead to sustainable solutions in short, medium and long term climatic conditions have been focused extensively in the kick-off, mid-term and finish line workshops, farm surveys, RAPs (Representative Agricultural Pathways), research articles, literature publishing in local language along with electronic and print media to educate and engage the stakeholders. An important milestone was a website (www.agmip.pk) developed by AgMIP-Pakistan IT team which is providing updated and full coverage of all stakeholder interactions. As a result more farmers, policy makers, students and a broad range of people got awareness of the climatic hazards to which Pakistan is highly vulnerable. This awareness campaign is now being heard properly in the Ministries of Climate Change, National Food security and well considered before making any decision for agriculture in Pakistan due to these Decision Support System (DSS) studies which were not previously done in broad scale from farm level to ministerial policy meetings and ultimately the food consumers. The first phase of AgMIP-Pakistan outreach activities has now been strengthened and upgraded to make stakeholder unit (SU) in Phase-2, which will foster collaboration with all the stakeholders from their feedback to delivery of strategic recommendations for adaptation as well as to reduce the vulnerability of farm and livestock systems in future changing climate scenarios.
SHAHZAD, H. ET AL. - ANALYSIS OF RAINFALL DATA TO ESTIMATE RAIN CONTRIBUTION TOWARDS CROP WATER REQUIREMENT USING CROPWAT MODEL

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A study was carried out to define the analysis of rainfall data in order to estimate its contribution towards crop water requirements to overcome water losses and scarcity problem. Rainfall and climatic data was collected from metrological stations, Crop Physiology Dept. University of Agriculture, Faisalabad (C.P. UAF) rain gauge (A), Ayub Agricultural Research Institute (AARI), (B), Civil Aviation authority (CAA), (C) and Water and Power Development Authority (WAPDA), (D), Faisalabad of given region and this data was reserved for cross validation. The test station’s (A) rainfall data was subjected to double mass curve technique to check its consistency with respect to other rainfall stations (B, C and D) in that area. The results derived by double curve technique were accurate for interested gauge station because there was no any break in curve. Then this consistent data was used to determine effective rainfall. The ETₜ₀ was established by using penman-monteith method in the course of CROPWAT model and its effect with respect to other parameters like sun shine hour, wind speed, maximum and minimum temperature and relative humidity were determined. It was founded that the reference evapotranspiration (ETₜ₀) is more during April to September due to increase in temperature and low in remaining months. After that data was placed in the model to acquire crop water requirement and irrigation of illustrative crops (wheat & maize) from the district. Through which we estimated that 7.5% rainfall for wheat and 15.5% rainfall for maize can contribute in actual irrigation per year. Through which we determined that 92.5 % and 84.5 % irrigation is required for wheat and maize crop, respectively.
SHAHZAD, H. ET AL. - ROLE OF ALLELOPATHIC CROP WATER EXTRACTS ON THE PRODUCTIVITY OF FORAGE MAIZE (ZEA MAYS L.)

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Fodder is a necessity for the livestock. As the increased population requires more grain for feed so the land for fodder production is declining with time passage. Some techniques leading to more yields of fodder with lesser land coverage have to be developed to overcome the situation. To go through this problem a field experiment to evaluate the influence of different allelopathic chemicals on the growth and yield of forage maize (Zea mays L.) was conducted at the Agronomic Research Area, University of Agriculture Faisalabad during the summer season 2013. The experimental design used was randomized complete block design with factorial arrangement. Net plot dimensions were be 1.8 m × 7 m. Two fodder maize varieties Pak. Afgoyee and Neelum were tested against foliar application of Brassica, Rice, Sorghum and Moringa extracts as allelopathic substances. Observations regarding plant height (227.87 and 218.46 cm), plant population (28.33 and 27.32), plant fresh and dry weights, green forage yields (454 and 457, 23.69 and 22.96, 81.65 and 80.91 g), protein, ash and fiber content were also recorded highest in the treatments subjected to foliar application of moringa leaves extract. The data recorded was analyzed statistically using Fisher’s analysis of variance technique and differences among the treatment’s means were compared using least significant difference (LSD) test at 5% probability level.
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The physical indices of the soil are major contributor in growth and yield of the crops. Soil texture is a stable soil physical characteristic that has an indirect impact on the crop growth. Present study aims to evaluate the impact of different textures along with organic amendments on root extension of maize that ultimately affect maize growth. A pot study was conducted at research area Institute of Soil & Environmental Sciences, University of Agriculture, Faisalabad in (2013) comprising two soils from Faisalabad and Gujranwala origin that are sandy loam and clay loam, respectively, along with application of farm manure at 0, 5, 10 and 15 Mg ha\textsuperscript{-1}. Recommended dose of NPK at 120: 60: 40 was applied in each treatment pot. A significant difference for plant growth parameters shoot (length, fresh weight and dry weight), root (length, fresh weight and dry weight) and 1000 grain weight was observed for application of organic amendment at different rates under different textures. It was observed that as the organic matter increased there was increase in every plant parameter but up to 10 Mg ha\textsuperscript{-1} and then a significant decrease was observed. It was also observed that crop performed better under sandy loam texture as compared to clay loam.
SUBASH, N. ET AL. - DEMONSTRATION OF ADAPTATION STRATEGY THROUGH MULTI-MODELING APPROACH FOR INTEGRATED ASSESSMENT OF CLIMATE CHANGE IMPACT ON AGRICULTURAL PRODUCTIVITY IN INDO-GANGETIC PLAINS OF INDIA

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The climate model projections based on IPCC AR5 CMIP5 models, reveal that surface air temperatures including night-time temperatures are expected to further increase in South Asia. The all-India rainfall is also expected to increase due to increased moisture availability and extreme rainfall events are also expected to increase in future. Under the business-as-usual scenario, mean warming over India is likely to be in the range 1-7-2.0 °C by 2030s and 3.3-4.8 °C by 2080s relative to pre-industrial times. All-India precipitation under the business-as-usual scenario is projected to increase from 4% to 5% by 2030s and from 6% to 14% towards the end of the century (2080s) compared to the 1961-1990 baseline. Under such situation, the agricultural productivity will decrease and thereby threat to food security and livelihoods of many small and marginal farmers, which constitutes 86 per cent of the total agricultural households.

Under this scenario, we have taken up a case study under AgMIP-ICAR Collaborative project, at Meerut District (29°4’ N, 77°46’ E, 237 m ASL), part of the Upper Gangetic region of the IGP, India to analyze the productivity, farm net return and per capita income under future climate by coupling climate-crop-economic models. This study is based on the farm survey (2012) data relating to 76 rice-wheat growing farms. We have used outputs of five GCMs (CCSM4, GFDL-ESM2M, HadGEM2-ES, MIROC5, MPI-ESM-MR) for the mid-century period (2040-2069) under RCP8.5. The APSIM7.5 and DSSAT4.5 crop simulation models were used for yield simulation under baseline as well as future climate scenarios. The TOA-MD (Trade-off-analysis and minimum data set) model used for economic analysis.

It is found that all the five GCMs predicted higher monthly mean maximum and minimum temperatures during the rice and wheat-growing season compared to baseline (1980-2010). It is also clear that there is lot of uncertainty in the case of monsoon rainfall projections by different GCMs. The mean net farm returns are likely to decline by 16% percent under pessimistic scenario in 2050s in Meerut District, if the current agricultural production system followed. Similarly, the per capita income would decline approximately by 10%. The single adaptation strategy of advancing of 10-days of sowing in wheat under projected climate scenario in 2050s is likely to result in an increase of 18.6% in mean net farm returns and subsequently the per capita income would increase by 11%. There is a need to include simulation of more crops and
livestock in the integrated assessment, to achieve more comprehensive integrated assessments. Similarly, a methodological framework should be developed for up scaling the integrated assessment from district to national/regional level.
The global change research community has recognized that new pathway and scenario concepts are needed to implement impact and vulnerability assessment that is logically consistent across local, regional and global scales (Moss et al. Science 2010). For global climate models, Representative Concentration Pathways (RCPs) have been developed; for impact and vulnerability assessment, new socio-economic pathway and scenario concepts have also been developed (Kriegler et al. 2012; van Vuuren et al. 2012, Global Env Change), with leadership from the Integrated Assessment Modeling Consortium (IAMC). One of the goals of these new developments is for them to be linked to sector-specific and regional pathways and scenarios. A major effort in this direction is the development of global and regional Representative Agricultural Pathways (RAPs), with leadership from the Agricultural Model Inter-comparison and Improvement Project (AgMIP). This poster will provide an overview of the RAPs concept and methods for their development within the integrated assessment framework developed by AgMIP and then illustrate their development and use by the AgMIP Regional Research Teams in Sub-Saharan Africa and South Asia.

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VELLINGIRI, G. ET AL. - IDENTIFICATION OF UNCERTAINTIES AND SENSITIVITIES IN CLIMATE CHANGE IMPACT ASSESSMENT ON RAINFED MAIZE IN TAMIL NADU USING MULTI-MODEL APPROACH

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Seasonal water scarcity, rising temperatures, and increase in the frequency of extreme weather events are making the Indian subcontinent a most vulnerable agricultural region. As majority of the Indian farmers belong to small and marginal category with less than one hectare land holding and their livelihood mainly supported from crop productivity, the adaptive capacity of the farmers to changing climate is very low. Understanding crop yield sensitivity to climate variability and future change is key to identifying effective adaptation and management strategies that can be adopted by rural communities to build climate resilience. A study was undertaken utilizing the Agricultural Model Intercomparison and Improvement Project (AgMIP, Rosenzweig et al., 2013) protocols to evaluate the sensitivity of baseline (1980-2010) rainfed maize yields to the fluctuations in important agro-climatic variables viz., maximum and minimum temperatures, rainfall and number of rainy days, using field level information gathered from the maize growing farmers of Coimbatore, Tamil Nadu. Impact of imposed future mean climate changes for near-term (2020) and mid-century (2055) periods, which generally show increases in both temperature and mean seasonal rainfall (IPCC, AR5, 2013) on the maize yield was investigated using Decision Support System for Agrotechnology Transfer (DSSAT, Hoogenboom et al., 2012), and the Agricultural Production Systems Simulator (APSIM, Keating et al., 2003) crop system models. Finally, adaptation strategies were identified by way of altered management at the field level, and implement these in the crop simulations, run under current and future climate conditions, to quantify their efficacy in terms of the yield improvement. The results derived from the analysis indicated that there is considerable variation and uncertainty in establishing strong correlations in climate-crop variability, which may be due to uncertainties in both the modeled yield and in the climate/weather data. However, some important agro-climate metrics are identified and assessed for current and future climate periods. Under future climate conditions, it was generally understood that the projected moderate increases in temperature and rainfall could contribute to small yield increases in the study region, which can undergo further gains with appropriate adaptation strategies. Such strategies will be important for rural, smallholder farmers to maximize their returns and fortify themselves against other potential negative impacts of climate change.
VILLALOBOS, F.J. ET AL. - IMPACT OF EXTREME METEOROLOGICAL EVENTS ON CROP YIELD: A COMMON FRAMEWORK APPROACH

Poster position: 36

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Crop models are usually assessed against long-term series of relevant outputs, while years with low yields or crop failure due to extreme, short-term meteorological events are usually treated as outliers. To improve the predictive ability of existing crop models to take into account the impact of extreme temperature (high and low) and water stress events, a framework of relatively simple yield-reducing functions is proposed. In most crops, extreme temperature and water stress events usually harm vegetative and/or reproductive organs (flowers or seeds), depending upon the phenological phase of the crop at the time of occurrence of the hazard, thus reducing their capacity of carbon assimilation and/or yield formation. Other crops never attain the reproductive phase and, if damages occur, they affect vegetative parts (e.g., sugar beet). The response functions of growth and yield to temperature extremes and water stress as devised here act by modifying the value of leaf area index (LAI) and the ratio between the biomass of reproductive organs and the total aboveground biomass, i.e. the Harvest Index (HI). These variables are reduced linearly between two critical levels of temperature or water stress (incipient and maximum damage). An extensive set of critical damage parameters account for stage- and crop-specific effects. The effects of the occurrence of multiple detrimental events are combined using appropriate relationships. This modeling framework is designed to target robustness, simplicity and broadness of application instead of detailed representation of specific processes. This required that some assumptions be made as, for instance, the linear increase of HI from flowering to harvest and the omission of processes, which harden plant tissues. Despite (or due to) these limitations, the approach is applicable to virtually any crop yielding fruits or seeds. Important advantages of the use of the approaches presented on the direct modeling of the effect of extreme events on relevant variables are: i) the absence of modifications in the source code, ii) the use of reducing functions at runtime to predict changes in the time step of the model, and iii) the preservation of the behaviour of the original crop model.

For extreme temperatures acting on the canopy for relatively short time, the suitability of using the air temperature as a surrogate of canopy temperature is not to be taken as granted in all situations. This is why fundamental components of the framework are a method for the calculation of canopy temperature from air temperature, involving several micrometeorological concepts, and a disaggregation method to obtain the diurnal course of air temperature from daily minimum and maximum values.
Experiment-Model Interface

ALI, A. - APPLICATION OF CERES-MAIZE MODEL FOR NITROGEN MANAGEMENT OF MAIZE HYBRIDS

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An experiment was conducted at Research Area of University College of Agriculture, Sargodha during the spring season of 2014 for the calibration and evaluation of CERES-Maize model to simulate nitrogen fertilization for maize hybrids. The experiment was laid out in split plot design having three replications, keeping hybrids in main plots and nitrogen rates (125, 175, 225 and 275 kg ha\(^{-1}\)) in the sub plots. The soil data, daily weather data, management data, seasonal crop growth and light interception was the input data for the model.

CERES-Maize model (DSSAT v4.5) predicted accurately the phenological events like anthesis phase and physiological maturity very close to the observed date. The model predicted lesser leaf area index than actually observed in the field. The model under estimated total dry matter as compared to actually observed in the field. The model predicted grain yield very close to the observed values, which showed the validation of the model under agro ecological conditions of Sargodha. The data suggested that there is considerable scope to exploit the yield potential of maize hybrids with various nitrogen rates, depending upon the prevailing climatic conditions.
BATTISTI, R. ET AL. - ASSESSMENT OF SOYBEAN YIELD WITH ALTERED WATER-RELATED TRAITS UNDER CLIMATE CHANGE IN SOUTHERN BRAZIL

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Water deficit is the main factor responsible for soybean yield gap in southern Brazil and tends to increase under the climate change scenarios. Alternatives need be identified in order to create options to reduce the yield gap. One alternative is the selection of soybean cultivars for current and future weather conditions with better traits associated with drought tolerance. Thus, the aim of this study is to evaluate soybean traits that can help to improve yield under the current and climate change scenarios in southern Brazil by improving the crop tolerance to water deficit. CSM-CROPGRO-Soybean was used for these simulations. CSM-CROPGRO-Soybean was calibrated for Brazilian soybean cultivar (BRS 284), using results of development and growth from field experiments conducted at different sowing dates, under rainfed and irrigated conditions at three locations in southern Brazil. In the next step soybean traits in the model were manipulated, and yield response evaluated for historical weather data from 1961 to 2014. Besides the current weather, soybean traits will be evaluated under climate change condition by the downscaling of regional climate forecast models for early (2025), middle (2055) and late (2085) periods, with a low and high CO₂ emission scenarios. The traits evaluated were: early reduction of transpiration under mild stress (conservation), modified root depth distribution, altered partitioning from shoot to root, grain filling acceleration, N₂ fixation drought tolerance and transpiration limited to a maximum rate. The field experiment showed a good range of yield, with results from near 1,000 to 5,000 kg ha⁻¹, and the large range helped to evaluate crop model performance under different climate conditions. The lowest yield levels occurred in the crop season 2013/2014 which had low rain and high air temperature. The irrigation applied during experiments help to produce soybean high yield, while the same sowing date under rainfed showed a low grain yield. Grain yield was well predicted after calibration process, with a mean error and absolute mean error of 63 and 446 kg ha⁻¹, respectively, which represent 2.18 and 15.5%, with low root mean squared error (549 kg ha⁻¹) and a high “d” value (0.93). Crop development was well predicted by CSM-CROPGRO-Soybean, showing low mean error of 1, 3, 2 and 0 and a mean absolute error of 3, 5, 5 and 3 days, respectively to anthesis, 1ˢᵗ pod, 1ˢᵗ seed and maturity. Preliminary results were simulated for the same sites where field experiments were conducted. High root resistance (reduced transpiration at mild stress) was responsible for anticipating soybean sensitive to water deficit, saving water early for later use. This trait showed a yield gain between 3 and 12% as a function of water deficit conditions, while in irrigated experiments yield was only reduced 1.12%, since when water is saved, photosynthesis is reduced. The root depth distribution was simulated with increased root growth factor in the 30 to 70 cm layer, resulting in a yield gain of 1 to 6% as function of water deficit, while yield did not change under no stress conditions. When the fraction of mass partitioned from shoot to root under deficit was changed from 1 (greater root adaptation) to 0 (no root adaptation), it caused a yield reduction of 5.85% and 3.04%, respectively at low and high water deficit. These crop model sensitivity analyses can be used to evaluate soybean traits under
different climatic conditions and regions, helping make soybean cultivar selection more efficient, defining guidelines for breeding programs, and allowing the saving of resources and time in the new cultivar development process focused on adaptation to current and future climate scenarios.
MOON, K.H. ET AL. - A SIMPLE GROWTH MODEL OF CHINESE CABBAGE USING RADIATION USE EFFICIENCY CONCEPT

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Chinese cabbage, a major ingredient of Kimchi, is one of the most important vegetables in Korea. We tried to develop a dynamic model of Chinese cabbage with the radiation use efficiency (RUE) concept. A chamber experiment was conducted to study the influence of temperature on Chinese cabbage growth and physiology using Soil-Plant-Atmosphere-Research (SPAR) units. Chinese cabbages were grown in six chambers with 6 levels of temperature treatments (14°C/9°C, 17°C/12°C, 20°C/15°C, 23°C/18°C, 26°C/21°C and 29°C/24°C of 16 hours of day time/8 hours of night time) under 400 ppm of CO₂ condition. The rates of leaf initiation, leaf area expansion and fresh weight increase of plant were increased from 14°C/9°C to 23°C/18°C and decreased to 29°C/24°C, and a quadratic relation was shown between logarithms of leaf number and leaf area. For making a simple model of Chinese cabbage, we choose a beta function to estimate leaf initiation rate and three linear functions to elucidate radiation use efficiency from daily temperature. In estimating dry weight from daily temperature and PAR using SPAR experiment data, the model performed well at 17°C/12°C, 20°C/15°C, 23°C/18°C and 26°C/21°C treatment, but was underestimating at low (14°C/9°C) and high (29°C/24°C) temperature treatment. But using field experiment data of altitude-experiment sites, the model usually was overestimating all of measured dry weights of Chinese cabbage. More study was needed to combine the effect of other environmental factors such as precipitation, nutrient supply on plant growth, and to improve model performance in open fields.
Projected adverse impact of climate change on food grain production of tropical and sub-tropical latitudes necessitates developing suitable agro-adaptations. We used open top chamber (OTC) experimental facility and simulation analysis to study the effect of elevated $[\text{CO}_2]$ with varying nutrients management on rice grain yield and to evaluate planting time adjustment as an adaptation to climate change. The OTC experiments with ambient $[\text{CO}_2]$ level ($[\text{CO}_2] \approx 390 \text{ ppm}$) and elevated $[\text{CO}_2]$ (25% higher than the ambient) using cultivar ‘Swarna sub1 (140-145 d)’ were conducted during wet seasons of the years 2011 and 2012 at Kharagpur, India. Using CERES model, we simulated rice grain yield for future climate scenario (A1B) during the years 2020 (2010–2039) and 2080 (2071–2099) at four selected locations of the sub-tropical India. The elevated $[\text{CO}_2]$ in OTC increased panicle number, but decreased filled grain number per panicle, thousand grain weight, and grain yield. The increasing $[\text{CO}_2]$ level had smaller adverse impact for integrated nutrients management as compared to chemical fertilizer. The model simulated grain yield reduction of 6.1 to 13.0% during 2020 and 14.4 to 25.0% during 2080 with rising temperature 1.6 $^\circ\text{C}$ and 4.6 $^\circ\text{C}$, respectively as compared to the base period (1961-1990). Planting during 25 June to 25 July received closure favorable temperature and rainfall during the crop growing period, hence had better adaptation to the climate change. Increasing dose of integrated nutrients and early planting is expected to minimize the adverse impact of climate change on rice production of the sub-tropical India.
ZHANG, L. ET AL. - DEVELOPMENT OF A QTL- AND ENVIRONMENT-BASED PREDICTIVE MODEL FOR NODE ADDITION RATE IN COMMON BEAN

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To select a plant genotype that will thrive in a specific environment, it is critical to understand the genotype by environment interaction (GEI). In this study, multi-environment QTL analysis was used on the main stem node addition rate (NAR, node d⁻¹) from field data of ~180 recombinant inbred lines (RILs) of the common bean (Phaseolus vulgaris) that were grown in five locations (Florida, Puerto Rico, 2 locations in Colombia, and North Dakota). Four QTLs (QTL10/Bng072, QTL28/FIN, QTL47/Bng083, and QTL285/DiM_7-7) were identified as significant, with QTL10 and QTL28 interacting with the environment (i.e., QTL by environment interaction, QEI). Temperature was subsequently identified as the main environmental factor affecting NAR and this interacted with QTL28, which is most likely to be the FIN gene responsible for determinacy; while day length played a minor role on NAR and interacted with QTL10. The environment covariates were integrated into a QTL mixed site-effect model and the final QTL- and environment-based predictive model explained 64% of the phenotypic variation for NAR with a bias of 0.5% and RMSE of 18.27% of the mean NAR. This model was able to predict NAR for an independent dataset of the same RILs with a RMSE of 24.88% and for the two parents (Calima and Jamapa) with a RMSE of 9.82%. These analyses suggest that QTLs are involved in node addition and also provide a model that links genes and environment for predicting NAR of common bean.
Crop Model Intercomparison and Improvement

BAN, H.-Y. ET AL. - EVALUATING THE PERFORMANCE OF A MAIZE GROWTH MODEL UNDER SUPRA-OPTIMAL TEMPERATURE CONDITIONS

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Crop growth models have been used to assess the impact of climate change on maize growth and yield. Reliable simulation of maize growth under high temperature condition would be essential in the impact assessment of climate change when a maize growth model would be used under the elevated temperature conditions in the future. The objectives of this study were to examine the performance of a maize growth model under supra-optimal temperature environments and to identify the modules of the model for further improvement. Field experiments were conducted to examine maize growth and yield under elevated temperature conditions. Early maturing maize hybrid cultivars including Chalok1 and Junda6, which were bred and grown in South Korea and northern China, were grown in plastic houses (37.27°N, 126.99°E; Suwon, Korea) in which temperature was maintained at ambient temperature (AT), and elevated to AT+1.5°C, AT+3°C, and AT+5°C. Modules of IXIM-Maize model, which is included in DSSAT 4.6, were modified to quantify kernel setting and to determine development rate under supra-optimal temperature conditions. The observed growth duration tended to decrease for both cultivars but not necessarily along with elevated temperature. The original IXIM-Maize overestimated the phenological development rates under supra-optimal temperature conditions, which resulted in shorter growth duration compared with the observed duration. As temperature was elevated, the observed grain yield tended to decrease due to the small number of kernel, which resulted from kernel set failure caused by poor fertilization and abortion under high temperature. IXIM-Maize has no subroutine to take high temperature-induced kernel set failure into consideration to estimate kernel number, which resulted in the overestimated kernel number and grain yield under elevated temperature conditions, especially in Junda6. The modified IXIM-Maize model had better accuracy in estimating maize yield compared with the original model. For instance, the root mean square error (RMSE) for days from emergence to anthesis decreased from 4.81 to 2.81, and from 3.23 to 2.32 for Junda6 and Chalok1, respectively. RMSE for yield reduced from 1039.9 to 595.6 and from 777.4 to 520.7 in Junda6 and Chalok1, respectively. These results suggested that IXIM-Maize model had limitations in simulating maize growth and yield under temperature elevation conditions, and this limitation could be improved through the modification of phenological response functions to the temperature and incorporation of the kernel set response function to temperature. It would be recommended that crop growth models for assessing the impacts of future climate should be calibrated and validated for variables that represent physiological and morphological properties that would be affected considerably under future climate conditions.
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BIERNATH, C. ET AL. - INCORPORATION OF AN OPTIMIZATION PRINCIPLE FOR NITROGEN ALLOCATION INTO A CROP GROWTH MODEL TO DESCRIBE WHEAT ACCLIMATION TO ELEVATED ATMOSPHERIC CO₂

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Crop models are widely applied to extrapolate crop biomass production and yield quality under expected future climate conditions, such as elevated atmospheric CO₂ concentrations, [CO₂]. It is well known that crop growth and yield quality strongly depend on multiple interactions of elevated [CO₂], among other environmental factors. However, due to different species and environmental conditions the observed parameter ranges of crop acclimation to these factors vary strongly. Acclimation responses include higher biomass production, lower tissue nitrogen concentrations, altered yield quality, and increased water and nitrogen use efficiencies. The lower tissue nitrogen concentrations are widely seen as a key factor of plant adaption. Therefore, various hypotheses exist to explain the decreased tissue nitrogen concentrations, but the mechanisms in terms of [CO₂] enrichment are still not clear. Also, the problem how to model crop adaption is not fully solved, yet.

We present a model that is based on the GECROS plant model. It was recently embedded into the Expert-N model environment. The new model accounts for the dynamic turnover of photosynthetic active nitrogen in the leaf. Mobile nitrogen derived from protein degradation is then available for re-distribution within the plant. In this way the plant can optionally use the re-mobilized nitrogen either for growth or for the optimization of the photosynthetic apparatus. Both the original and the new model were tested against data of spring wheat grown in a Mini-FACE system. The sensitivities of both models to [CO₂] enrichment were analyzed. The new model predicts an altered vertical distribution of protein within the canopy under [CO₂] enrichment. This results in an increased simulated biomass production and a higher shoot:root-ratio compared to the original model.
BREGA, M. - DEVELOPING A COMPREHENSIVE NITROGEN MODEL FOR NITROGEN ADVISOR

Moorea Brega

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Nitrogen availability for crop growth and development is one of the key issues that growers must manage. Many factors influence this availability as represented by the nitrogen cycle. It is not feasible to directly track availability across fields, so The Climate Corporation is working to incorporate known factors into a model that will guide management decisions through a user interface. Data from external sources is ingested for our use and we have developed extensive field protocols to enhance that information base.
With the increase of atmospheric CO$_2$ concentration, assessment of the impacts of this abiotic factor on crop development, growth, and yield using mechanistic models becomes increasingly important. Open-field Free Air CO$_2$ Enrichment (FACE) studies offer data to test and improve model quality and should be used more intensively. From this perspective, the objective of this work is twofold: 1) to test multiple maize models for CO$_2$ responses against data gathered from a FACE study under two water regimes carried out in Germany during 2007 and 2008, and 2) to pave the way to potential model modifications so as to improve their simulations of crop responses to CO$_2$. In order to achieve these objectives, a two-phase methodological approach was adopted. Firstly, after a preliminary calibration based on the WET AMBIENT treatments of both years, a blind simulation was undertaken for the other treatments: WET FACE 2007 and 2008, DRY AMBIENT 2007 and 2008, and DRY FACE 2007 and 2008. Secondly, with full growth and yield data along with soil moisture data of all treatments, improvements of simulation results were attempted. Changes made to the models have been documented and submitted for further analysis. The results revealed: minimal CO$_2$ effect variations among « uncalibrated » models except for the dry season of 2008; most models caught but underestimated the CO$_2$ impact on crop water status and leaf area but the CO$_2$ effect on transpiration was generally properly simulated. As more data from FACE experiments become available, it will be highly desirable to replicate this exercise in order to come up with more robust conclusions on these responses and to improve model response to CO$_2$. 
HLAVINKA, P. ET AL. - CROP GROWTH AND SOIL PROCESSES MODELING - THE USE OF GROWTH MODEL ENSEMBLE FOR CROP ROTATIONS UNDER RECENT AND FUTURE CLIMATIC CONDITIONS

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The goal of this study is to analyze the performance of crop models in simulating crop rotations through evaluation of the soil water and organic matter balance, yields and other aspects associated with cropping systems. The crop model ensemble represents 12 modeling groups using eight different crop models. The study focuses on three production areas in Central Europe (warm-dry; warm-wet and cool-wet). As Central Europe is considered among climate change hot-spots with a large degree of uncertainty about the prevailing character of the ongoing climate change it makes this study particularly important for strategic decision making in countries like the Czech Republic. As a pilot a single model approach was used with the HERMES model which is represented here. The crop rotations (including spring barley, silage maize, winter wheat, winter rape, and winter wheat) were simulated over the period from 1981 till 2080. The period 1981-2010 is covered by measured meteorological data, and the period 2011-2080 is represented by a transient synthetic weather series from the weather generator M&RI (for 5 GCMs representing the whole ensemble of CMIP3). The long-term effects of two types of crop management (i.e. different approaches in terms of crop residues and organic fertilizers supply) were compared within the study.
JONES, M.R. ET AL. - EVALUATION OF FOUR SUGARCANE MODELS FOR SIMULATING CLIMATE CHANGE IMPACTS AT SITES IN SEVEN COUNTRIES

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Realistic assessment of future climate change impacts on sugarcane production is essential for strategic planning, and accurate crop simulation models are important tools in this process. This poster reports on the activities of the AgMIP sugarcane model intercomparison project, which seeks to assess the suitability of sugarcane models for simulating sugarcane growth and yield under a wide range of environments across the globe under current and possible future climates. Experimental data from 35 treatments, in 10 experiments at sites in Australia, Brazil, Ecuador, Reunion, South Africa, the USA and Zimbabwe were used to calibrate six models (DSSAT-Canegro (v4.5.1, 4.5.2 and 2D), APSIM-Sugar, Mosicas and QCane) in two stages: (1) ‘blind’ calibration, whereby only management, weather and soil data were provided, and (2) ‘phenology’ calibration, which added crop development observations. One of the models was subjected to a sensitivity analysis in order to demonstrate this process: 30 seasons of sugarcane growth were simulated at each site, using historical weather data perturbed by changes to daily air temperatures (-3, 0, +3, +6 and +9°C), rainfall (-25, -10, 0%, +10 and +25%) and atmospheric CO2 concentration ([CO2], +90, +190, +290 and +390 ppm). Outputs were analysed with scripts developed using PHP and R statistical software. For the first stage, the root mean squared error (RMSE) of predicted stalk dry mass (SDM, t/ha) at harvest was 15.97 t/ha (42% of observed mean) on average for all models. SDM RMSE values decreased by about 10% on average from calibration to phenology data in stage 2, although sucrose mass RMSEs increased by 2%. This study revealed differences in modelling approaches (e.g. calibration via changing soil parameters vs changing genotype parameters) between different modelling groups, which will need to be addressed in order to ensure consistency going forward. Another challenge is the inconsistent availability of observations and observed variables across sites. The sensitivity analysis showed minimal fresh cane yield (CY, t/ha) responses by DSSAT-Canegro v4.5.2 to rainfall and [CO2] changes, because the experiments were mostly irrigated. CY increased with +3 °C but generally decreased with -3, +6 and +9 °C. This behavior was deemed consistent with current knowledge and accepted theory. The study highlighted the need for global model testing in diverse environments and production scenarios, rather than local testing, which may lead to model-fitting by unwarranted parameter adjustments. This study is ongoing, and will include a third calibration stage which adds observations of biomass, and for the sensitivity analysis to be applied for all models. Other anticipated activities include comparing simulations of actual climate change projections at each site, and elaboration of model improvements.
LI, T. ET AL. - THE EVALUATION OF MULTIPLE RICE MODEL RESPONSES TO ELEVATED CO₂

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One of the major objectives of the AgMIP Rice Team is to quantify the rice model response on rice production to elevated CO₂. The team has tested model sensitivity of rice yield predictions to elevated CO₂ by evaluating 7 to 12 models against data from Free-Air CO₂ Enrichment (FACE) and Soil-Plant-Atmosphere Research (SPAR) chamber experiments. The yield increases varied among models from 3 to 38% in response to an increase in CO₂ from 360 to 540 ppm. Model responses also varied across different sites - the lowest being 3 to 21% increase at the subtropical humid site (Nanjing, China) while the highest was 3 to 38% at the subtropical arid site (Ludhiana, India) and cool temperate site (Shizukuishi, Japan). However, the ensemble response of all models (mean) showed that predicted response to CO₂ elevation was an increase of 0.07 to 0.09% ppm⁻¹, which was not significantly different from the measured responses in FACE. The ensemble mean of all model simulated CO₂ fertilization effects were not significantly different from observed (simulated 0.0501 vs. observed 0.0495% ppm⁻¹ at Shizukushi, and 0.0792 vs. 0.0771% at Wuxi). With provision of incomplete cultivar information (‘blind’ simulations), simulated yield increases to elevated CO₂ varied among models and were very different to FACE observed CO₂ fertilization effects at low nitrogen fertilizer application, at which most models did not represent the measured responses. Notably, similar as observation, the simulated CO₂ fertilization effects increased with the increase of nitrogen fertilizer, confirming that the interaction between nitrogen and CO₂ on rice growth is important for improving model response to CO₂ elevation. To further confirm the responses to CO₂ evaluation, these models were further evaluated against data from SPAR chamber experiments. Most models could confidently represent the CO₂ fertilization effects when CO₂ concentration was between 330 to 660ppm, but large uncertainties existed at which CO₂ concentrations...
exceeded this range. The ensemble of current rice models is reliable for quantifying the independent CO$_2$ fertilization effects on rice growth and yield. However, single model may generate large uncertainty, and the interactions among CO$_2$, nitrogen and temperature will probably increase the uncertainties in evaluating the impacts of climate change on rice production.

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PEQUENO, D.N.L. ET AL. - EVALUATION OF THE NEWLY-LINKED DSSAT-ORYZA COMPARED TO ORYZA V.3 FOR SIMULATION UNDER POTENTIAL, WATER-LIMITED, AND N-LIMITED CONDITIONS

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The use of multiple model approaches is a valuable goal to evaluate uncertainty of crop models for their response to climatic, soil, and management factors. There were two objectives in this work. The first objective was to incorporate the rice crop simulation model, ORYZA, into the Decision Support System for Agrotechnology Transfer (DSSAT) software platform. This followed a wrapper approach in which the ORYZA plant growth code, with no modification, was linked to the DSSAT Cropping System Model (CSM), and thus uses the soil water balance and the soil carbon-nitrogen balance of the CSM. The second objective was to evaluate the performance of the linked DSSAT-ORYZA model to the original standalone ORYZA under potential production, water-limited, and N-limited production environments. For potential production, the simulated outputs were exactly equivalent for the two ORYZA versions. In experiments in the China, the maximum LAI was 8.16 at 78 days after planting, while the potential above ground biomass was 17152 kg ha⁻¹, and yield was 8470 kg ha⁻¹. In an experiment in the Philippines, the outputs were identical under potential production for both models. Maximum LAI was 5.25 m² m⁻², above ground biomass was 16200 kg ha⁻¹, and panicle weight was 9183 kg ha⁻¹. For water (China) and N-limited (Philippines) simulations, the models gave different outputs, with DSSAT-ORYZA being closer to observed data than the standalone ORYZA which was not sufficiently sensitive to water or N stress. Under N-limited conditions, DSSAT-ORYZA gave similar predictions as standalone ORYZA, although it was more sensitive to N stress associated with less soil N mineralization. If the DSSAT-ORYZA was simulated with 100% deep urea N fertilization to minimize NH3 volatilization, the simulations were much improved and DSSAT-ORYZA predicted LAI, biomass, and panicle quite well. The over-predictions in the N-limited experiment by standalone ORYZA appeared to be associated with too much N available from soil N mineralization. The two models were relatively comparable and predicted well under water-limited production, although DSSAT-ORYZA was somewhat more sensitive to water stress, resulting in lower biomass and grain accumulation, associated with much higher soil evaporation and slightly lower transpiration. These differences are attributed to the different methodologies between DSSAT-CSM and standalone ORYZA for soil evaporation, transpiration, soil C mineralization, soil N balance, and root soil water uptake. However, the two models show reasonably good prediction of observed data, but with more necessity of improvements mainly for low nitrogen and water treatments. Additional data are needed to test the comparability of predictions for DSSAT-ORYZA to standalone ORYZA v3.
RAYMUNDO, R. ET AL. - PERFORMANCE OF SUSTOR-POTATO MODEL ACROSS CONTRASTING GROWING CONDITIONS

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Crop models became an important tool in climate change impact assessments, but often lack comprehensive field testing. We tested the SUBSTOR potato model with 87 field experiments including 204 treatments from 19 countries. The field experiments varied in cultivars, N fertilizer and water supply, sowing dates, soil types, temperature environments and atmospheric CO\textsubscript{2} concentrations and included open top chamber (OTC) and Free-Air-CO\textsubscript{2}-Enrichment (FACE) experiments. Tuber yields were in general well simulated across a wide range of current growing conditions, for diverse potato species and cultivars, including \textit{Solanum tuberosum}, \textit{Solanum andigenum}, \textit{Solanum juzepczukii} species and modern, traditional, medium and late maturity-type cultivars, with a RMSE of 2.1 Mg ha\textsuperscript{-1} for tuber dry weight, and 5.3 Mg ha\textsuperscript{-1} for tuber fresh weight. Tuber yields were less responsive to elevated atmospheric CO\textsubscript{2} and had difficulties in simulating high temperature impacts on crop growth. Single cultivars (cv. Desiree and cv. Atlantic) grown across the globe using constant cultivar parameter sets were well simulated with the model. Other simulated crop variables like leaf area, stem weight, crop N and soil water often differed substantially from measurements; however, some of these variables had also significant measurement errors indicated by large error bars. The SUBSTOR Potato model was found suitable for simulating current growing conditions and crop management options across geographic regions but requires improvements in simulating high temperature and elevated atmospheric CO\textsubscript{2} impacts before being used in climate change impact assessments.
RITCHIE, E.J. ET AL. - PREDICTING ON FARM WHEAT YIELDS: DEVELOPMENT AND COMPARISON OF A STATISTICAL AND A BIOPHYSICAL MODELLING APPROACH

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The prediction of wheat yields has been the focus of numerous modelling studies due to its global importance. The models developed range from relatively simple, statistical models, derived from large observational datasets, to detailed, process-based models, describing large numbers of interacting biophysical processes. Although process-based models are widely used in modern crop modelling research, they usually require large numbers of parameters to describe cultivar, management and soil characteristics. Statistical models require large, but less detailed, datasets and can be advantageous at broader scales, when parameters of process-based models are difficult to define. Yield predicting crop models are mainly developed using research trial data, and are applied at field or large scales. There are limited examples of models developed using farm observations, or investigation of the controlling factors for yield in the farm situation. To address this deficiency, we developed two models – a statistical and a semi-empirical, biophysical model – using nationally collected monthly meteorological observations and annual farm management information (Farm Business Survey, FBS) collected for official statistics. The FBS dataset included financial and physical farm data, including nearly 3,400 yield observations, from 700 farms over the period 2005-2010. The dataset was randomly split for use in model development (75%) and model testing (25%). The statistical model was generated using stepwise regression and the biophysical model was selected from a number of candidate model designs and parameterised using the Metropolis-Hastings algorithm. The resulting statistical model included 10 meteorological and 13 farm management variables, explaining 41% of the variation in observed yields in the independent dataset. Management variables were more important predictors than climate variables. The selected biophysical model described wheat growth on a monthly time step driven by radiation and temperature, with the potential for loss of biomass under high rainfall and enhanced canopy size with increased fertiliser and crop protection expenditure. It explained 25% of the variation in yield in the independent dataset. In both models, the majority of the explained variation was attributed to crop protection and fertiliser expenditure. The biophysical approach could be further developed to include additional descriptions of variables identified as significant by the statistical model, for example farm area, which had a significant positive effect on yield. The project dataset of monthly and annual observations are likely more suited to the statistical approach, especially with the lack of date records for sowing, harvest and chemical applications. Collection of FBS data is ongoing and collaboration with the modelling community could direct the addition of useful data, including these dates that would be especially useful in the further development of the biophysical model. Additional data has been collected that could also be utilised includes crop rotation records, and recently the number and type of fertiliser applications.
Global warming is projected to alter thermal regimes of the Earth’s major cereal grain production regions. Hence, it is more likely that cereal grain crops will experience an increase in episodic periods of thermal stress for a longer duration. Nevertheless, the deleterious effects of thermal stress may be mitigated through adaptation strategies. A need exists, therefore, to elucidate thermal tolerant mechanisms in cereal grain crops and to what extent genetic controls are available for adaptation. Then, such findings need to be incorporated into crop growth/ecosystem models that accurately simulate interactive effects of temperature and other environmental variables based on first principles in a more mechanistic manner.

Globally, the semi-arid desert region of Maricopa, Arizona, USA experiences some of the widest ranges in high temperatures over the course of a year (-2 to 42 °C). So, seasonal and inter-annual variations in natural temperature provide a cost effective means to obtain robust dataset for multiple cereal grain crops simultaneously. Prior work on wheat (*Triticum aestivum* L. cv. Yecora Rojo) revealed a lethal season-long average air temperature of 32°C or higher, so we intend to stagger planting dates – from the normal cropping season in December – to be at closer intervals in the April-May time frame to refine thermal response curves at higher temperatures. These selected planting dates will ensure that predominately cooler-to-warmer thermal regimes will occur up to and including thermal death. Experimental artifacts such as photoperiod, soil properties, vapor pressure deficit, precipitation, and solar radiation are unavoidable, and may complicate interpretation of thermal response. Nevertheless, use of day-neutral cultivars without a vernalization requirement will minimize photoperiod effects and ensure floral induction regardless of planting date.

Our objectives are: (1) determine cereal grain crop responses to a wide range of air temperature via planting date; (2) quantify crop growth; (3) evaluate and refine thermal response on crop growth and development; (4) validate crop growth models with regard to thermal dependent processes believed to be mediated through canopy energy balance. Our hypotheses are: (1) thermal response will be similar among cereal grain crops, nevertheless species and cultivar specific parameterization will be required to accurately depict any differences in thermal response; (2) plant organ temperature, rather than air temperature, will provide the most accurate depiction of thermal response to Genotype x Environment interactions; (3) deleterious effects of thermal stress on cereal grain crops will occur at acute thermal regimes ($T_{critical}$), that will be dependent on growth stage when thermal stress occurs.

Study materials include: Wheat (*T.aestivum* L.); Durum Wheat (*T. durum* L.); Barley (*Hordeum vulgare* L.); Triticalea (*TriticumSecale*) WheatxRye. Overall, 4 cereal grain crops, over 8 planting dates, for 4 replications, over 2 years will provide 256 differently treated crop responses over an air temperature range from -2 to 42 °C.
These data will be assembled and formatted in accordance with ICASA Version 2.0 standards, and be distributed to the AgMIP-wheat team for model improvement/validation as deemed appropriate.
Coordinated Climate-Crop Modeling Project (C3MP)

RUANE, A. ET AL. - THE COORDINATED CLIMATE-CROP MODELING PROJECT (C3MP)

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The Coordinated Climate-Crop Modeling Project (C3MP) is mobilizing the international community of crop modelers for coordinated climate-crop impacts assessments 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 submit their results for coordinated analyses resulting in 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, which may be more robust across crop models and locations than are the absolute yields. By coordinating an investigation into these fundamental sensitivities, C3MP enables assessments of projected climate impacts across a range of global climate models, regional downscaling approaches, and crop model configurations. Currently, C3MP has contributions representing over 18 crops, 56 countries, and 23 crop models, with more contributions anticipated as the project continues. As more crop modelers contribute, 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 carbon, temperature, and water sensitivities with today’s climate as the origin, C3MP results will also facilitate the identification of key vulnerabilities and urgent interventions. Preliminary analyses reveal thresholds for major yield changes as well as the probability that these thresholds will be exceeded in several ensembles of global and regional model projections. To demonstrate the utility of this international effort, this poster describes the C3MP methods and protocols; presents a sampling of results from around the world; and highlights the types of analyses we aim to undertake.