Speaker Abstracts

Speaker	Title	Abstract
Aggarwal, Pramod	Adapting to increasing climatic risks in South Asian agriculture: Oppotunities and constraints	Agriculture and food security in South Asia have always been affected by climatic risks. IPCC reports and other studies predict increased probability of extreme weather events in the region, leading to greater instability in food production and threatening livelihood security of millions of farmers. Many studies indicate a probability of 10-40% loss in crop production in India and South Asia by 2070-2100 unless steps are taken to increase our adaptive capacity. Several technological, institutional and policy interventions can help South Asia adapt to climate change and to current and future weather variability. Adaptation strategies include modifying planting dates, bridging yield gaps, deploying adverse climate tolerant genotypes and diversified land use systems, using solar irrigation, assisting farmers by providing value-added advisory services and crop/weather insurance, and improving land and water use policies. Most of the proposed adaptation options, if implemented scientifically, also have mitigation co-benefits. CCAFS is scaling out the Climate-Smart Villages (CSVs) model in South Asia to promote climate-smart agriculture (CSA). Climate Smart Villages are sites where a portfolio of the most appropriate technological and institutional interventions, determined by the local community, are implemented to increase food production, enhance adaptive capacity and reduce emissions. A critical analysis of recent data indicates that these strategies have reduced the impact of rainfall deficits and temperature increases on an aggregated scale, although significant problems persist at local/sub-national levels. While most of these interventions have shown increased production, resilience and even mitigation, efforts are needed to increase their coverage. This requires understanding the adaptation domains of CSA practices, their linkages with demand and supply of food grains, and appropriate 'business models' to scale them out. Efforts are simultaneously needed to address the complex problems of widespread poverty, poor governance, weak institutions, and human capital to realize the full potential of CSA practices.
Antle, John	Assessing how agronomic and economic adaptations affect vulnerability to climate change	Adaptation to climate change can occur through both agronomic and economic changes in management and other factors that affect agricultural system performance. This presentation introduces a framework for adaptation and vulnerability assessment that shows how both bio-physical and economic adaptations can be incorporated. Examples from REACCH and AgMIP studies in the U.S. and Africa will be presented.
Aubinet, Marc	Is eddy covariance a suitable tool to establish greenhouse gas balance of cereals?	Eddy covariance is a tool that allows trace gas exchanges (water vapor, carbon dioxide, methane, nitrous oxide, VOCs) between terrestrial ecosystems and atmosphere to be measured. The method provides measurement with a high time resolution (half hourly) and for long periods (several years). This makes it a relevant tool to study greenhouse gas exchanges by cereals and to establish their carbon balance. We took example from our experiments developed at the Lonzée Terrestrial Observatory (Belgium), where an eddy covariance system installed since 2004 above a crop rotation provided continuously measurements of carbon dioxide exchanges, allowing the establishment of the carbon budget of a five year rotation (two years of winter wheat, potato, sugar beet). In addition, the method allowed evaluation of the impacts of climate and of cultural activities on the CO2 exchanges.
Barton, Louise, D. V. Murphy and K. Butterbach-Bahl	Nitrous oxide fluxes from cropping soils in a semiarid region in Australia: A 10 year perspective	Western Australia's wheatbelt includes 7 million hectares of arable land producing up to 40% of Australia's grain exports. The region has a semiarid climate with winter-dominant rainfall and hot, dry summers; also described as a Mediterranean-type climate. Cropping is confined to the winter months with soils fallow at other times of the year. The soils are derived from highly weathered materials, generally coarse-textured, and low in soil organic carbon (SOC) and nutrients. Nitrogen fertilizer (mainly urea; up to 100 kg N ha^{-1} per year) is applied as split applications at seeding and during the growing season depending on crop requirements. Ten years of *in situ* measurements from various sites have confirmed nitrous oxide (N_2O) fluxes are small (0.04–0.27 kg N ha^{-1} yr^{-1}) and represent <0.12% of applied N fertilizer. Including grain legumes in cropping rotations has not enhanced soil N_2O fluxes in the growing season or post-harvest. Increasing SOC elevated soil N_2O fluxes, but losses represented <0.12% of the N fertilizer applied. Developing strategies for mitigating N_2O fluxes from cropping soils in our region is challenging as losses occur post-harvest, when there is no active plant growth, and in response to summer rainfall rather than N fertiliser additions. Strategies that control soil N supply from nitrification following soil wetting, or immobilise excess inorganic N via soil microbial or plant uptake, would be expected to decrease the availability of N for subsequent N_2O losses. We have demonstrated that increasing the efficiency of the nitrification process, by increasing soil pH (via liming), can decrease N O fluxes from sandy, acidic soils following summer rain. Accurately accounting for N_2O fluxes in our region has refined Australia's national greenhouse gas inventory and demonstrated that on-farm greenhouse gas emissions represent a low proportion of the total emissions from grain production.

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Bartuska, Ann M.	A sustainable approach to climate-adapted agricultural production	At the United States Department of Agriculture (USDA), much of our work is focused on finding solutions to the unprecedented challenges facing the global food and agricultural system. These challenges include producing enough safe and nutritious food for a growing population, adapting to a changing climate, building the bioeconomy, and conserving our natural resources. We recognize that healthy and safe food and water depend on healthy and safe agriculture and natural resources. Agriculture and natural resources are at the crossroads of the world's most critical problems. The food system in the United States is critical infrastructure and relies on climate-adapted agricultural production. The increased extreme weather events in the U.S. have forced farmers to actively attempt to grow crops under hotter, drier climate regimes and protect their crops from damage during extreme weather events. Farmers are dealing with seasonal changes in precipitation; increased variation in temperature and precipitation; both among and within years; changes in weather patterns in season; and an increase in temperature and precipitation extremes. Our approach to dealing with the complexities of a sustainable food and agriculture system recognizes investments need to be made in new and emerging technologies, and promotes open access to data even while accelerating efforts in animal and plant genomics. All of this must be done at a global scale, even as we enhance our domestic efforts. Matching global monitoring of agriculture (e.g. GEOGLAM) and linking to agricultural productivity models that incorporate climate change response (e.g. AgMIP) are important tools for accomplishing our objectives. USDA continues to make great strides in understanding the effects of climate on agriculture and developing climate-smart agricultural varieties and practices. The Department's scientific research and technology investments directly support sustainable intensification, or what some call the 'triple win concept' of increasing productivity and maintaining resilience, while achieving mitigation.
Calderini, Daniel, D.J. Miralles, A. del Pozo, G. García	Climate change and cereal cropping systems of South America: The sensitivity and adaptation of cereals in the sub-continent	In South America, cereals such as maize (97.2 M t y-1), rice (24.3 M t y-1), wheat (21.1 M t y-1) and barley (4.3 M t y-1) are key crops for food and feed uses. This subcontinent has huge variability through agroecosystems, from the tropics to cold areas and from very productive to bare soils. This complexity means that the climate change will affect the cereals cropping systems in different ways. Present scenarios estimate the temperature increase between 1 and 4°C for 2050 in South America; however, changes of 4-4.5°C are expected, for example, in maize areas of Brazil. The forecast accuracy of rainfall is affected by the influence of El Niño SO in South America. Remarkably, contrasting rainfall scenarios were predicted for bordering countries like Chile and Argentina since decreasing rainfall is expected for Central-South Chile, while western semiarid Argentina will be beneficiated by higher rainfall. Consequently, cereal systems of Chile started to move southern and the wheat sowing area of semiarid Argentina increased. Several studies highlighted the negative impact of climate change on cereals but positive impacts are also expected, even in summer crops regarding that maize yield would increase 30% or more in some temperate/cool areas. The main effect of higher temperature on C3 cereals will be the shortening of the crop cycle without impact on either interception efficiency (k) or RUE. On the other hand, higher environmental CO_2 concentration could balance the negative impact of temperature (improving WUE under water shortage); however, the trade-off between temperature and CO_2 could be over-compensated by temperature in environments of South America. A key for assessing the impact of climate change on cereal cropping systems will be the differential sensitivity of the crop phenophases and the management strategies to mitigate the climate change conditions, e.g., grain setting and grain filling.
Craufurd, Peter and Kindie Tesfaye	Global challenges and opportunities for adaptation of cereal systems in sub-Saharan Africa	The IPCC has concluded that the mean annual temperature has increased over Africa and that further increases are very likely. Changes in current rainfall patterns are less clear, but consensus projections indicate that all regions will be wetter, except for southern Africa where a drying trend is anticipated. Increased frequency and severity of extreme climatic events such as severe storms, flooding and droughts are also very likely. Maize, sorghum, millet, wheat and rice are all important cereals in SSA, with maize being the dominant food security crop. Meta-analyses suggest that cereal yields, with the exception of rice, will decline by 5-20% on average by 2050 with regional and mega-environment differences. The risk of hunger is likely to increase significantly in East and Southern Africa where calorie consumption is low. Maize for example, which makes up 70% of the cited IPCC studies, is predicted to show positive to neutral impacts in high and upper mid-altitude mega-environments, as well as negative impacts in dry mid-altitude and lowland environments. Areas suitable for production are also likely to change, with some gains but more losses. Simulation studies also suggest that maize losses will be higher at higher nitrogen rates. In terms of adaptation, both short and longer duration varieties will be needed. For example, in the savannas of West Africa, local photoperiod-sensitive varieties will fare better than improved varieties. In maize and rice, where heat stress at flowering is a major threat, heat tolerant lines have been identified. Drought tolerant lines have also been identified and are being released and transgenes are ready for testing. The fact remains, however, that in SSA adaptation is, and will likely continue to be, affected by policy and institutional options that limit access to technological innovations.

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Devare, Medha	Overview of CGIAR's Open Access, Open Data efforts	In its first phase (2015), CGIAR's Open Access and Open Data initiative focuses on assessing current Open Access/Open Data (OA/OD) resources, practices, and needs across Centers, strengthening collaboration and coordination around tools and approaches within CGIAR and external communities, developing a framework for prioritizing data to be initially made open, and for impact assessment. The second phase envisioned for 2016 and 2017 will build on this work to render CGIAR outputs standards-based and interoperable, and ensure that they are discoverable and accessible via integrated and contextualized views across Centers and CRPs, type (e.g., publications, data, etc.), and discipline (e.g., genetic/genomic; agronomy; breeding; natural resource management; socioeconomic; geospatial, and other sectors). Most Center repositories represent silos whose contents are not generally easily discoverable or inter-linked where appropriate and useful (e.g., agronomic trial data with socioeconomic or adoption data in the same geography). In the absence of such interoperability-mediated discovery, "open" is of very limited utility. The overall objective, then, is to make CGIAR's trove of research data and associated information completely accessible for indexing and interlinking by a robust, demand-driven cyberinfrastructure for agriculture, ensuring that research outputs are open via FAIR principles – that is, Findable, Accessible, Interoperable and Re-usable to enhance innovation, impact, and uptake. Creating a strong data-sharing culture, addressing data quality issues through interventions throughout the data life cycle, and developing the technical infrastructure to enable this goal are key focus areas for CGIAR's OA/OD activities in the immediate future. This talk will provide an overview of the status quo and planning for the next phase of OA/OD across CGIAR.
Dzale, Esther Yeumo Kabore	Wheat data management and sharing guidelines	The Wheat Initiative (WI) (www.wheatinitiative.org) aims to reinforce synergies between bread and durum wheat international research programs to increase food security, nutritional value and safety, taking into account societal demands for sustainable and resilient agricultural production systems. In 2012, the WI conducted a survey highlighting the wide diversity of wheat-related data formats and the lack of standardization. Research on wheat can and must make optimum use of currently available data to feed the growing global population. Increased computing power allows for more sophisticated analyses with 'mega databases". The Wheat Data Interoperability (WDI) working group, within the umbrella of the WI, was endorsed by the Research Data Alliance (RDA) in 2014. The 15 active members include wheat scientists, data and metadata technologists from national and international organizations: CIMMYT, CSIRO, INRA, FAO, IRD, Bioversity, ACPFG, Planteome, Agro-Know. The WDI aims at building common framework to foster the reuse and interoperability of wheat data. The WDI use the EIF definition: An interoperability framework is an agreed approach to interoperability for organizations that wish to work together towards the joint delivery of public services. Within its scope of applicability, it specifies a set of common elements such as vocabulary, concepts, principles, policies, guidelines, recommendations, standards, specifications and practices. The deliverables include: recommendations on data exchange formats; data description best practices (consistent use of vocabularies, consistent use of external database cross references, etc.); and data sharing best practices. The WDI portal gathers wheat-related vocabularies and ontologies and makes them accessible through APIs. The expected benefits are: bioinformaticians and data managers who will find relevant information on existing data and metadata standards, avoiding duplicating efforts; and integrated wheat information systems using computation and modelling tool designers who will be able to easily discover access, interpret, aggregate, and analyze data from different sources.
Fitch, Peter, Simon Cox, Peter Lemon, and John Kirkegaard	Agricultural information supply chains: Drivers and directions	Interest in better use of agricultural information is exploding. The drivers for this explosion are many and varied and include technological drivers such as improvement to computers, sensors, smartphones, emergence of the cloud, better analytics and so on. At the same time there is pressing need for enterprises to be more productive, more profitable, look after the land and water resources used for production, whilst becoming more resilient to a changing climate and to resilient to market shocks. Opportunities for use of information abound, the information age is finally making its presence felt in agriculture. On many farms today crop yield information is automatically and routinely collected and stored on the cloud. It is combined with other information such as soil nutrient and climate forecasts and a range of management products are created, which can be downloaded directly to the enterprise for use. A custom prescription for your farm can be quickly generated and used, resulting in significant on-farm benefits. This talk reviews the current ways in which agricultural information is transferred, accessed and shared across the agricultural information landscape. We identify that one major issue is that often this data is commercially sensitive and needs to be managed accordingly. We also identify the need for open standards and interfaces to access and use data and identify where work in other domains such as water, can be helpful.
Fixen, Paul	Nutrient use analytics for climate-adaptable nutrient management strategies	Management of cropping systems under changing climatic conditions will likely benefit from evidence-based approaches to input decisions and the assessment of system performance. In the case of nutrient management, nutrient use analytics have a key role to play in guiding decisions concerning nutrient stewardship and system performance. Meaningful nutrient use analytics cannot be limited to efficiency measurements, but must include assessment of the effectiveness of nutrient use in obtaining intended outcomes. Scalability is highly desirable where the same metric can be applied at an individual field or farm scale as well as at a watershed, state or national scale. Many exciting new technologies and decision support tools are entering the agricultural scene that can enable the kind of site-specific management that will be essential for proper response to changing climatic conditions and inform farmers about nutrient source, rate, time, and place decisions. Scalable performance metrics can facilitate adoption of these technologies by farmers and offer science-based guidance to policy makers in developing programs to accelerate that adoption.

Speaker	Title	Abstract
Garrett, Karen	Managing disease in cereal systems	The risk of crop losses to disease is strongly tied to weather, so climate and climate change are key risk factors. Crop breeding for resistance to pathogens and herbivores is one of the most important tools for adaptation to climate change, and breeding strategies also must address climatic variability. Impact network analysis (INA) is a framework for evaluating information and technology impacts through linked socioeconomic and biophysical networks, identifying system strengths and vulnerabilities. It can be used to assess the likely or realized impacts of strategies for adaptation to climate change and climate variability. Two key examples of such impact networks are system-level management of new invasive diseases, and crop breeding networks that determine how limited pools of disease resistance genes are deployed across landscapes.
Garrett, Karen	Agricultural systems that enhance translation	Participatory research offers the potential for improved system outcomes, such as resistant varieties and other IPM strategies better matched to stakeholder needs. Including a participatory research component generally requires additional investment, so it is useful to know under what circumstances the investment is rewarded and how participatory research can be optimized. Impact network analysis (INA; introduced in abstract above) provides a framework for evaluating the likely benefit of including participatory system components. Key factors determining the effects of including a participatory component include the degree of farm heterogeneity, the effects of which can be better understood through wider participation, and the degree of mismatch between the perceived priorities of farmers and scientists. Optimization strategies can be devised to efficiently address these factors.
Gessler, Paul, E. Seamon, E. Flathers, S. Eigenbrode, C. Stöckle, L. Sheneman, and D. Vollmer, D. Huggins	Evolving an architecture for agricultural research data management in the US Pacific Northwest	The Pacific Northwest of the US has an estimated $US 21 billion agricultural sector critical to the economic well-being of the region. The USDA NIFA funded Regional Approaches to Climate Change for Pacific Northwest Agriculture project (REACCH) has stimulated the development of a research data management framework to store and enable interactive analysis of data from regional land grant universities, state experiment stations, and USDA ARS research units. REACCH contributes to a growing number of research data sets managed collaboratively by the Northwest Knowledge Network, which further provides support systems and applications, as well as connections and interoperability with other national and international research data management efforts. These data and systems, collectively, represent critical assets accumulated from funded research and a wealth of information for understanding potential changes and impacts to agriculture and society in the region. They also serve as the basis for new science based on data exploration, analytics, and data mining using these multi-disciplinary and multi-scale spatiotemporal data. This talk will overview the development of this network of resources and data along with the cyberinfrastructure, data policies and funding mechanisms aimed at sustaining access to these critical data assets. The ongoing development of new data interoperability techniques and analytical methods requires that our systems continually evolve to take advantage of new portal capabilities, data collection technologies, and analytical techniques that can operate over a diverse set of distributed data repositories. We will also discuss ongoing efforts for the establishment of a national agricultural data management network as well as other initiatives that are providing alternatives for data access and analysis.
Govarets, Bram	Increasing productivity in rain fed, semiarid systems by analyzing and remediating limiting factors	In semiarid, rain fed production systems, water is the principal factor limiting crop productivity. To achieve sustainable intensification in these systems, innovation systems approaches have to support the development of innovations that optimize rainfall use efficiency to cope with both heavy rainfall events and prolonged drought. Optimizing rainfall use efficiency will make it possible to further increase productivity by addressing other limiting factors in the system like nutrient deficiencies. The presentation will show examples from long-term experiments and component technology trials with maize and wheat in the Mexican highlands that evaluate conservation agriculture and fertilization to sustainably increase productivity. Conservation agriculture is based on minimizing soil movement, crop rotation and retaining permanent soil cover through crop residues or cover crops, and has been shown to improve soil quality. In the studied long-term experiments conservation agriculture especially increased soil physical quality compared to conventional practices involving tillage, and zero tillage with residue removal. Improved parameters include soil aggregate stability, direct infiltration and soil water content during dry periods. Conservation agriculture also increased yield compared to conventional practices, and more so in more diverse crop rotations. We compared the application of N fertilizer at different moments to a zero N application control under conservation agriculture and conventional tillage. Under conventional tillage, yields were low and similar with and without N fertilizer application, whereas with conservation agriculture yields were higher than in the conventional practice without N fertilizer, and there was an additional yield increase with fertilizer application. The results show that conservation agriculture should be the base for sustainable intensification of rain fed semiarid cereal systems, in order to fully seize the benefits of other technologies such as optimized fertilization. In order to reflect these scientific insights, innovation systems approaches will connect the scientific knowledge with farmer innovation while fostering multi-sectorial public private partnerships.

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Grace, Peter	Optimizing yield and reducing greenhouse gas emissions for resilient cropping systems in rain fed semiarid environments	The paucity of greenhouse gas emissions data that exists in semiarid climates makes it difficult to outline generalized agronomic and economic decisions which maximize crop productivity and at the same time provide significant mitigation potential. The value of traditional site specific agronomy trials in combination with greenhouse gas monitoring can be greatly enhanced through the use of simulation models which combine soil, crop and atmospheric processes. Data from a high temporal resolution automated global greenhouse gas monitoring network with multiple treatments focusing on N2O reduction has been used with a selection of simulation models to develop robust mitigation strategies which take into account nitrogen management, crop rotations and climate variability. These examples provide confidence in the ability of simulation models to develop regional strategies for improved food security and reducing greenhouse gas emissions.
Greatrex, Helene D.E.O. Osgood, J. Hellin, J.W. Hansen	The role of index insurance in semiarid cereal systems	There are many solutions posed to the challenges facing cereal farmers in semiarid regions, not least new varieties of seed and/or alternative management practices. However, the risk of severe drought or another climate shock can limit the uptake of these innovations. The risk of loss in a 'bad year' is often too great for a farmer to be able to invest in an otherwise productive opportunity. Weather based index insurance and other financial tools have recently been promoted as a way to help farmers manage their climate risk, and subsequently, to invest in inputs and technology that can increase their yields and income. For example, insurance has been shown to be useful in enabling farmers to access credit to purchase improved seed and other inputs, or to cover specific components of risk that existing safety nets cannot cover. There are now many insurance programs active in the world, some operating as pilots and some reaching thousands, or millions of farmers. This talk examines some of the features that an index insurance program might need in order to scale and the multiple roles agronomists and other actors can play in this process. It also reports on new research in insurance design and delivery, utilising tools such as crop simulation models, livelihood mapping and economic research games.
Han, Xue; Erda Lin, Wei Xiong	New findings for climate change and food security in China	After the releases of IPCC AR5 and China Second National Assessment Report for Climate Change, some suggestions were proposed based on new findings for food security. Warming was notable since 1980 in China, coinciding with widespread yield stagnation. Warming has been blamed as a driver for past yield stagnation, but the effects of warming largely cancelled out in different latitudes showing a small net effect of warming on China's food production. Increased pollution was another important player for reducing crop yields over past decades. Adaptation to warming could improve food production, and still had huge potential impacts. A large potential exits for production, if climate-smart agriculture is applied. To answer whether China's food production can deal with a 2°C warming world, a current assessment suggests a 2°C warming has limited effects (less 5%, even without CO_2 effect) on China's total food production. Current adaptation can utilize this small warming and turns it with more inputs with as there may be more opportunities to increase production but uncertain picture under a 4°C warming. Water could be one big barrier for future food production. More concerns will be focused on international food trade trends.
Hatfield, Jerry L.	Cereal production systems in North America: Challenges for effective adaptation	Cereal production in North America is located primarily in rain fed climates and show large variation in production among years due to soil water availability. Adaptation to an increasing variability in precipitation during the year requires increasing attention to water management to meet crop water demands. Effective adaptation strategies will have to include quantifying the risk to the potential exposure to extreme temperatures and variable precipitation regimes. Cereal production can be enhanced through linking climate adaptation with improved genetic resources and agronomic management.
Herren, Hans R.	How to transition cereal systems from problem to solution to the climate change challenge	Cereal based systems worldwide are of crucial importance to food and nutrition security on a global scale. Their importance however in the contribution to Climate Change has grown exponentially, not only with greater surfaces, but also because of the farming practices that accompanied their global spread. To over reliance on a growing amount of cereal commodities of a fewer number of species and genetic diversity in all cereal producing areas has led to a number of challenges that need to be addressed urgently, at the root causes, should we tackle the multiple challenges posed by this steady move towards simplified and reductionistic systems. There are many great solutions to many of the challenges as we will see and hear about in this symposium. The main issue will be to give a close look at how to implement these solutions respecting the need to address the three dimensions of sustainable development, the environment, society and economy. The trend to simplify and increase the efficiency in the production process has left a trail of problems that a world which has moved beyond many off the planetary boundaries can no longer afford. The vital ecosystem services, upon which our production bases depends, has been replaced by unsustainable, subsidy fueled business options and a reversal of this trend is an urgent necessity to assure the medium and long term production of food, feed and fiber. One will note the absence of the word energy, that is with purpose. As main mechanism to induce and carry out a full transformation, at global scale, of cereal systems, and the linked consumption patterns that have been fueling the present unsustainable production pathways, full cost accounting is seen as the best leverage point. Time is now to introduce regenerative, agroecological agriculture practices across the board, and without delays, the ice is melting, the seas are rising; climate change is knocking at the door, to ignore it would at best be irresponsible, at worst criminal. We have truly sustainable solutions, we have choices, lets make the correct ones, now.

Speaker	Title	Abstract
Jones, James W.; C. E. Vallejos, Melanie Correll, Salvador Gezan, Cheryl Porter, Chris Hwang, and Kenneth J. Boote,	Improving models and data for developing pathways for cropping system adaption to climate change	Cropping system models are widely used to study climate change impacts and adaptation of cropping systems globally. However, a number of studies have recently shown considerable uncertainty in current crop models relative to their abilities to simulate production when they are carefully compared with each other, and these uncertainties increase under high CO_2 levels and high temperatures. These studies, conducted by contributors to the Agricultural Model Intercomparison and Improvement Project (AgMIP), clearly point out that model improvements are needed to increase their effectiveness in research on transitioning crop production to adapt to climate change. We discuss two critical areas in which the agricultural science community must advance in order to achieve the next generation of models for these purposes. The first critical area involves developing a culture for preserving research data over time and space and tools for harmonizing data so that anyone wanting to evaluate or improve models will have access to data from varying environments and management systems. Existing crop models have been developed by using data from only a few environments and few cultivars. Another critical area is a need to better represent the genetic diversity of crop responses to environment and management factors. This is needed to enable virtual research with crop and economic models to estimate the combinations of genotypes and management that best fit within current and future climate conditions. In this paper, the authors will describe recent developments in gene-based modeling of cropping systems that are needed for next generation crop models and an approach for harmonizing typically-collected data in crop research trials that promises to considerably increase data discovery, access, and use by models and other quantitative analysis methods.
Khan, Zeyaur	The 'Push-Pull' farming system: Climate-smart sustainable agriculture for cereal-livestock production in Africa	The climate-smart 'push-pull' system (www.push-pull.net) effectively controls serious biotic constraints to cereal production in Africa (insect (stemborers) and striga weed) while improving soil health and biodiversity. The companion cropping system makes smallholder farms more resilient often with a tripling of yields. It involves attracting stemborers with trap plants (pull) whilst driving them away from the main crop using a repellent intercrop (push). Chemicals released by intercrop roots induce abortive germination of the noxious parasitic striga weed. The companion plants provide high value animal fodder, facilitating milk production. Furthermore, soil fertility is improved due to the nitrogen fixing intercrop and soil degradation is prevented. To date climate-smart push-pull has been adopted by over 42,000 smallholder farmers in eastern Africa.
Kirkegaard, John A., James R. Hunt, Julianne M. Lilley, Susan J. Sprague, Lindsay W. Bell, Clive A. Kirkby, Mark B. Peoples, Andrew L. Fletcher, Therese M. McBeath, Rick Llewellyn	Innovations in Australian mixed cropping systems under climate change	Australia's broad-acre cropping occurs in mixed crop-livestock enterprises with phases of wheat-based cropping sequences rotated with legume-based pastures grazed by sheep. The biophysical and economic elements of such "ley-farming" systems have been considered some of the most sustainable worldwide. The recent intensification of cropping systems at the expense of pasture area has involved a 50% reduction in sheep numbers and an intensification of cropping under no-till farming systems, with the inclusion of oilseed (canola) and grain legume break crops. Changes in climate are already evident with drier autumn planting periods, more variable rainfall and warmer temperatures and changes in the occurrence and severity of damaging frosts. Despite these challenges, new cropping system innovations and flexible crop-livestock options are maintaining crop productivity increases with a focus on system water-use efficiency and management of risk. Recent national research initiatives on whole-farm water-use efficiency, integration of dual-purpose (grain-graze) crops, strategic tillage, increased adoption of break crops, inclusion of perennial plants and consideration of intercropping have all addressed aspects of system resilience. Features of the research that improve the likelihood of adoption include the use of crop and whole-farm simulation in the analysis of risk, and the close interaction between growers and researchers in local field-based research to embed social and economic imperatives from the outset. We discuss recent research highlights and whole-of-system synergies that generate significant improvements in resource-use efficiency and productivity in the face of this farming system evolution and a changing climate.
Lemke, Reynald	Constraining soil-emitted GHGs from crop production on the Canadian semiarid prairies	Agricultural soils are a significant contributor to anthropogenic greenhouse gas emissions and approaches to reduce these emissions must be identified. Concurrently, the human population's food requirement is projected to double from present levels by 2050. Consequently there is an urgent need to identify cropping practices that will not only improve yields but also minimize GHG emissions. The first step towards addressing these seemingly mutually exclusive requirements is to ensure a clear understanding of the sources, sinks and drivers of the greenhouse gas emissions associated with crop production. The preponderance of greenhouse gas research on the Canadian prairies has focussed on spring seeded wheat (Triticum aestivum); however the selection of crops grown by producers in this region has expanded remarkably in recent years. This paper will provide a brief overview of the current state of understanding of greenhouse gas emissions from the Canadian semiarid prairies and then present data generated from recent studies targeted towards understanding the impact of more diverse crop sequences on soil-emitted greenhouse gases. An evaluation of these cropping systems based on yield-scaled metrics will be considered, as well as discussion regarding how the information may point towards potential opportunities to constrain emissions from cropping systems in the region.

Speaker	Title	Abstract
Liebig, Mark	Greenhouse gas mitigation potential of dryland cropping systems in the U.S. Great Plains	The U.S. Great Plains contain significant expanses of agricultural land dedicated to dryland cropping. Dryland cropping systems in the region that sequester soil organic carbon (SOC) and minimize nitrous oxide (N_2O) emissions can serve to reduce the greenhouse gas (GHG) balance of U.S. agriculture. This presentation will summarize effects of dryland cropping on SOC dynamics and N_2O flux in the U.S. Great Plains, and discuss outcomes in the context of anticipated climate change. Among cropping practices, continuous cropping combined with no-tillage management appears most effective at sequestering SOC. Accrual of SOC in these systems has accompanying benefits to agroecosystem performance through increased crop productivity and improved soil quality. Assessments of N_2O flux in the region are limited, but suggest low-to-moderate emission rates under most cropping systems. Anticipated changes in climate are projected to vary considerably across the region, making blanket recommendations for GHG mitigation difficult. Projections suggest adaptive, multifaceted management approaches will be needed to minimize the GHG footprint of dryland cropping systems in the U.S. Great Plains.
Lobell, David	An 80/20 approach to climate change adaptation in cereal systems	Much of what is required to improve cereal systems in the face of climate change are the same things that we'd need even if the climate was not changing. These include general needs such as robust breeding and agronomy research capacity, and more specific needs such as improved drought tolerance. Thus, a large fraction (say, 80%) of "adaptation" resources aimed at improving agriculture should focus on these things, as they often represent the most cost-effective investment strategies. At the same time, climate change opens up some unique risks and opportunities -- things we could safely ignore if the climate was not changing. Effective adaptation involves not pitting old needs vs. new needs, but rather identifying the right investments to make in each category. One way to achieve this balance is to focus modeling and experimental work on identifying investments that have significantly higher or lower value in future vs. current climate. Some examples of this type of work will be presented.
Macfadyen, Sarina	From impact assessment to climate change adaptation: What do we need to know for invertebrate pest management in grains	Extensive research has shown that climate change will have a range of direct and indirect impacts on invertebrate pests of broad-acre crops. However, much less attention has been placed on translating these likely changes in pest outbreak risk into practical management options for growers. Using climate change projections for major pests of Australian grain production systems as a case study I will highlight areas for future research that will provide knowledge that will lead to improved management in the short-term, but also facilitate adaption to climate change in the long-term.
McCarl, Bruce	What we know about public and private adaptation strategies	McCarl will draw on IPCC reports and his work to identify possible adaptation strategies, and who might implement them, including arguments about public goods and a needed public role. He will also review findings on what adaptations have been observed and the relative value of multiple actions.
Motavalli, Peter	Perceptions and management of soil quality: A translational approach	Development of sustainable land use practices and systems are urgently required because of widespread soil degradation from poor land use practices and the negative effects of climate change in some regions. Soil quality has been described conceptually as an assessment of the soil's capacity to support a particular function, such as serving as a medium for plant growth, and scientific approaches, such as the soil management assessment framework, have been developed for soil quality evaluation. In this presentation, the importance of assessing local perceptions of soil quality and community feedback on appropriate soil quality indicators and tests in the development, adoption and monitoring of sustainable land use practices and systems will be addressed.
O'Leary, Garry J., and David J. Connor	Adapting cereal cropping systems to a changing climate in Australia	Since the introduction of mechanization crop production in Australia has undergone significant adaptation resulting in increased productivity. This adaptation exceeds what could be attributed to changing climate over the last 100 years. The early analyses of the historical climate in Australia reveal high variability with extended wet and dry periods. Lack of water is the major limitation to productivity. Despite these serious challenges Australian agriculture remains efficient and productive and the idea that cropping systems will need continuing adaptation to climate change, as well as to technology and prices, is not new. According to climate change projections, typical declines without adaptation by 2030 are estimated at around 8% for wheat in the temperate south and over 12% for sugarcane in the sub-tropical and tropical north. Beyond 2030 greater losses around 12% are projected for wheat. FACE experiments and other studies show that such losses might easily be compensated by the greater atmospheric CO_2 concentration in some locations, but additional uncertainty is introduced because of lower grain quality and the yet-to-be-established response of crops to higher temperatures. The technical solutions will involve closer monitoring of soil water, water conservation strategies and multiple sowing times using different crops to reduce risks. The management of pests and disease will be an added burden especially in higher rainfall areas. Advancement will be incremental, always with the aim of increasing productivity and/or efficiency. Technical solutions alone are, however, insufficient to affect a sustained adaptation to significantly different environments. Social, economic and regulatory constraints will also determine the course of adaptation and these will require careful consideration and implementation. We argue that crop production can be increased for an increasing world population in the face of climate change but do not underestimate the challenge and the need for wide participation from farmers, society and government.

Speaker	Title	Abstract
Pan, William	Flexible cropping system design is required for climate and social change and fluctuation	Climate change forecasts stress long term, trending changes in mean precipitation and temperatures, while not being as capable of predicting the degree of annual and seasonal fluctuations. Similarly, there are long term trends in markets of farm inputs and products, but also seasonal and annual fluctuations governing these markets. Farmers flexibly react to these fluctuations to make cropping system adjustments on-the-go. Designs of future systems will require general frameworks for design, but they will also require an integration of flexibility components that will allow these real-time adjustments. A few examples of potential flexible systems in the Inland Pacific Northwestern U.S. will be discussed.
Pulwarty, Roger S. and Douglas Kluck	Transitions and transformations-climate extremes, hotspots, and adaptation, in semiarid regions	All aspects of food production and security are affected by climate. As the IPCC notes, projected impacts vary across crops, regions, and adaptation scenarios. For major crops (wheat, rice, and maize), climate change without adaptation will have negative impacts, although individual locations may benefit. A range of adaptation options exists. However, many analyses assume a fixed or "changed" climate without accounting for changes in extremes as these evolve to 2050 and beyond. Systems, and equilibrium assumptions, may change faster than models can be recalibrated, and projections may be most unreliable at the time when they are most desired. Key factors are intra-seasonal (extremes) to decadal variability effects on quantity, quality, and access, including crop migration, storage and utilization. There remains limited understanding of impacts and adaptation options for non-production elements. We will address the factors driving a changing climate, sources of knowledge and uncertainty in characterizing hotspots in the U.S. and elsewhere, impacts on productivity, and adaptation priorities. We argue that immediate needs are to; acknowledge the cross-scale nature of climate, of early warning information and of climate-resilient strategies affecting food production and security, including critical interdependencies derived from water and land resources; recognize that communication is a necessary but limited framing-as important, is an understanding how particular lessons become socialized into practice over time; craft an acceptable, fundable, collaborative framework between research-management. Key factors determining success in the above dimensions, include; food production assessments linked with food security assessments; information services to support adaptation in changing environments; and empirical evidence on the effectiveness of technological interventions and social adaptations at all levels of the food system. Most critical will be development of sustained networks across institutions to ensure that lessons being learned, as risks and opportunities emerge, become embedded in practice and inform the choice of pathways for resilience.
Wulfhorst, J.D.	Agro-ecological classification of farmer risk perceptions and climate adaptation	The presentation will focus on perceived risk of changing environmental conditions from climate variability such as long term drought, less reliable precipitation, and fewer days with frozen soils. Agro-ecological class designations are used to delineate geographic and social community variability for risk perceptions. Data for the analysis were generated from a 2012 survey of 900 Inland Pacific Northwest farmers who participated in a social survey as part of a large regional Coordinated Agricultural Project focused on climate change.
Ziska, Lewis	Weeds, rice and climate change: A new paradigm?	Among global cereals, rice is recognized as a primary source of calories for approximately one-third of the global population. Weed induced losses in rice cultivation can be severe, resulting in 100% loss if weeds are not controlled. Climate change, including rising CO_2 levels, warmer temperatures and precipitation extremes (drought, flooding), will differentially affect rice and associated weeds. To date, published studies indicate that red rice, recognized as a ubiquitous weed in rice systems, is likely to respond more to recent and projected CO_2 levels than cultivated rice, with additional crop losses. Weed management in turn is also likely to be impacted. For example, diminished water supplies are affecting traditional flooding-transplanting weed control, and increasing reliance on herbicides. In addition, increasing CO_2 is facilitating greater genetic outcrossing (and diminished chemical control) in herbicide resistant rice cultivars such as Clearfield. While there is an urgent need for additional information, the data to date indicates that weed-rice interactions and weed management in rice systems are likely to be negatively impacted by climate change with subsequent consequences for global food security.