Anderson, Christopher
Iowa State University

ENSO Signals in Seasonal Predictions Made with a Regional Climate Model Given Forecasts from NCEP CFS

The Multi Regional Climate Model (RCM) Ensemble Downscaling of NCEP CFS Seasonal Forecasts (MRED) project will produce a multi-decade data set of forecasts from seven regional climate models driven by ensemble forecast data from global seasonal forecast models. The ensemble will consist of multiple global models, multiple RCMs, and multiple initial conditions. The presentation will provide a brief overview of the data set of 3-hourly output that will be made available to the research and applications communities.

Preliminary results from one member of the RCM ensemble, the WRF-NMM, will be discussed. In particular, the ENSO signal in precipitation, temperature and severe weather parameters will be presented.

Averyt, Kristen
NOAA, Western Water Assessment
University of Colorado

An Uncertainty Framework for Regional Climate Assessments?

Co-authors: Jenifer Martin (University of Colorado at Boulder), Jessica Lowrey (University of Colorado/NOAA/Western Water Assessment), and Brad Udall (University of Colorado/NOAA/Western Water Assessment)

Lack of knowledge regarding uncertainty associated with climate models and projections can hinder decision-makers from implementing climate adaptation strategies.

A formalized scientific uncertainty rubric may prove a valuable tool for those using climate information for regional adaptation planning. The Intergovernmental Panel on Climate Change (IPCC) uses standard uncertainty terminology to convey degrees of scientific uncertainty to international policy makers; both quantitative, probabilistic assessments (very likely (>90%), likely (>66%), etc.) and more subjective confidence assessments (high confidence, etc.) are used by the different IPCC Working Groups. This terminology has become an integral part of the international science policy vernacular. The US Global Climate Research Program adopted similar terminology for its Scientific Assessment Products (SAP). However, the different SAP documents used different likelihood expressions. The lack of homogeneity complicates the communication of scientific uncertainty in support of regional adaptation planning, as regional climate syntheses cull statements from different sources including the IPCC Assessment Reports and USGCRP SAPs.

For example, in crafting the Colorado Climate Report, a document developed by the Western Water Assessment (WWA) to support adaptation planning for water managers, statements incorporating uncertainty language were culled from many IPCC and SAP Reports. Although quoting IPCC and SAP statements containing uncertainty terminology proved useful to the Colorado Report audience, there was no mechanism for the WWA to apply "likelihood" and "confidence" terminologies to the state-specific studies not included in international and national assessments. Developing a regional uncertainty framework for the Colorado Report was not practical given the short time line for developing the report and the small team of scientists working on the project (relative to the IPCC).

Here, we propose a discussion of different approaches to addressing uncertainty in regional climate issues. Specifically, we propose a discussion framed around the following questions: Is an uncertainty index necessary? Would an uncertainty index based on the IPCC and USGCRP models tailored to regional climate issues be valuable to users? Likelihood or confidence—which is more useful for adaptation? At what point does a user decide that a climate projection actionable? Can a model be developed in collaboration with stakeholders and decision-makers? This is intended as a springboard for building a model of uncertainty communication with users of regional climate information, and assessing the utility of standardized likelihood.

Baigorria, Guillermo A.
University of Florida
Agriculture and Biological Engineering Department

GiST: A New Geosptio-Temporal Weather Generator

Co-author: James W. Jones (University of Florida)

Weather generators are tools developed to create realizations of synthetic daily weather data for long periods of time. These tools have also been used for downscaling monthly to seasonal global and regional circulation model forecasts to daily values to provide daily inputs to crop and other environmental models. The main limitation is that weather generators do not take into account the spatial structure of weather and climate in a given region or watershed. Thus, the use of existing point-based weather generators produces daily data that do not account for the correlations that exist among sites in a neighborhood. This spatial correlation is important when we try to spatially aggregate, for example, simulated crop yields or water resources in a watershed or region. A method was developed to generate realizations of daily rainfall for multiple sites in an area that preserve the geospatial and temporal correlation among sites. This two-step method generates first rainfall events following rainfall amounts on places where a rainfall event is expected. Generation of rainfall events were based on the new developed 'Two-state orthogonal Markov chain for discrete distributions'. For generating rainfall amounts, the correlation matrix of order equal to the number of weather stations was factorized using Toeplitz-Cholesky decomposition method. A vector of the same order containing random numbers following Gaussian distribution was matrix-multiplied by the corresponding Toeplitz-Cholesky matrix to create correlated random numbers. Elements from the resulting vector of geospatially correlated random numbers were transformed to a gamma distribution using the cumulative probability function calculated individually for each weather station. Then, the resulting numbers were used to generate rainfall amounts for each site where a rainfall event was expected to occur. Seven weather stations around North-Central Florida were selected and a thousand years of daily rainfall data were generated for this study. For rainfall events and amounts, the proposed method was compared to the WGEN point-based weather generator. As a result, the geospatial daily rainfall data generator reproduced the observed monthly spatial Pearson's correlations between all pairs of weather stations and monthly rainfall statistics of each weather station, including the two-state first-order Markov transitional probabilities. Correlation values between observed and generated correlations among weather stations were 0.976 and 0.985 for rainfall events and amounts, respectively, and significant at the probability level of 0.01. Root mean square errors ranged from 0.025 to 0.101 for rainfall events whereas from 0.033 to 0.063 for rainfall amounts.

Barsugli, Joseph
CIRES, University of Colorado at Boulder

Lake Mead's Future: Out of Water or Out of Context?

Co-authors: Ken Nowak (Dept. of Civil, Architectural, and Environmental Engineering/University of Colorado at Boulder), Balaji Rajagopalan (Dept. of Civil, Architectural, and Environmental Engineering/University of Colorado at Boulder), Martin P. Hoerling (NOAA Earth System Research Laboratory), Andrea J. Ray (NOAA Earth System Research Laboratory), Benjamin Harding (AMEC Earth and Environmental), and Bradley Udall (Western Water Assessment)

The journal article "When Will Lake Mead Go Dry?" by Barnett and Pierce was published in early 2008 and ignited a firestorm of media coverage in the Southwest. Many stakeholders became aware of the work through the media reports, or from the press release that was issued prior to publication, allowing little time to formulate a scientifically informed response. In the days and weeks after the release, it became clear to us that, while it is an interesting paper in its intent, the authors had made several fundamental errors, including factual errors and a failure to properly put their results in the context of existing policies and agreements.

We will present two threads of the story: first, the coverage of the Barnett and Pierce study in the media and the public reactions from several stakeholders, and second, our scientific reaction, including an analysis of the risk to the Colorado River water supply using a corrected version of the Barnett and Pierce water balance model. We perform this analysis in the context of several management and growth options along with the policies and timetables agreed to in the Interim Guidelines adopted in December 2007. We conclude that the combined threat to Colorado River water supply due to climate change, demand growth, and episodic drought becomes large following the mid-2020's, giving a decade or more of breathing room compared to the Barnett and Pierce analysis. We also conclude that flexibility within the existing system can mitigate much of the near-term risk, and that there is probably a window of opportunity within the existing guidelines to put into place policies that will act to mitigate the longer-term risk.

Simplified models, such as the one used by Barnett and Pierce, can help to frame the discussion of issues regarding Basin-scale risks and focus research on outstanding scientific issues. However, if this framing – and the modeling -- lacks the proper context then it can obscure, rather than illuminate paths to mitigate these risks. In the case discussed here, the ongoing interaction of the Western Water Assessment (a NOAA Regional Integrated Science and Assessments group located at the University of Colorado) with the Bureau of Reclamation and other stakeholders on the River has enabled us to provide a more accurate and, we hope, more credible risk assessment.

Barsugli, Joseph
CIRES, University of Colorado at Boulder

Climate Change in Colorado: Scientific Challenges in Preparing a Statewide Assessment

Co-authors: Andrea Ray (NOAA Earth System Research Laboratory) and Kristen Averyt (Western Water Assessment, University of Colorado at Boulder)

In response to the risks associated with anthropogenic climate change, Governor Ritter issued the Colorado Climate Action Plan (CCAP) in 2007. In support of the adaptation component of the CCAP, the Colorado Water Conservation Board commissioned the Western Water Assessment at the University of Colorado to prepare the report "Climate Change in Colorado: A Synthesis to Support Water Resources Management and Adaptation." The objective of "Climate Change in Colorado" is to communicate the state of the science regarding the physical aspects of climate change that are important for evaluating impacts on Colorado's water resources. Accordingly, the document focuses on observed trends, modeling, attribution, and projections of hydroclimatic variables that are important for Colorado's water supply. Although many published datasets include information about Colorado, there are few climate studies that focus on the state. Consequently, many important analyses for Colorado are lacking. The report summarizes Colorado-specific findings from peer-reviewed regional studies, and presents new analyses derived from existing datasets. Here we will summarize the findings of the report, discuss the extent to which conclusions from West-wide studies hold in Colorado, and highlight the many scientific challenges that were faced in the preparation of the report. These challenges include interpreting observed and projected precipitation and temperature variability and trends, dealing with attribution and uncertainty at the state level, and justifying the relevance of climate model projections in a topographically complex state. A second presentation (Ray et al.) discusses the process of developing the report.

Breuer, Norman
University of Miami

Enablers and Barriers to Climate Forecast Use in Agriculture in Two Distant Study Areas

Co-author: Clyde W. Fraisse (University of Florida)

Ex ante assessment is a fundamental aspect to consider when implementing climate research projects that aim to develop decision support systems for risk reduction in agriculture. Knowledge, attitudes, and perspectives of potential end users with regard to seasonal climate variability are typically elicited through a number of social science methodologies at or before the initiation of research. Farmers' intimate knowhow of their agricultural systems coupled with their knowledge of variability patterns in their production area are crucial data needed to first understand vulnerability and resilience, and then develop adaptation strategies at feasible entry points where farmers are willing to alter current practices. Data from surveys, interviews, and group discussions in two agricultural production areas –Rio Grande do Sul, Brazil - Eastern Paraguay, and the Southeastern United States are analyzed and contrasted. Sample population size was 154 in South America and 319 in Alabama, Georgia, and Florida. Results show variable levels of ENSO effects knowledge and willingness and to apply climate forecasts for adapting management practices. Farming in South America is done under more homogeneous soils and with large-scale ownerships. This contrast with farming In the Southeastern United States, which presents a mosaic of land ownership classes and more diversified production system. Finally, the consulting/extension paradigm differs between the two study areas. In South America farmers are organized into strong cooperatives that provide technical assistance whereas in the USA, the public Cooperative Extension Service is used. Properties that may enable or present barriers to use and adaptation through climate forecasts are discussed. Further study should explore the potential for designing enablers and reducing barriers into agricultural systems and their socio-economic support institutions.

Bukovsky, Melissa
University of Oklahoma

Changes in Summertime Precipitation Over the U.S, Due to Climate Change as Simulated by the WRF Model

Co-author: David J. Karoly (University of Melbourne)

Select simulations from the NCAR Community Climate System Model (CCSM) version 3.0 run for the IPCC 4th assessment report are being dynamically downscaled using the WRF model to 30km resolution to provide more detailed estimates of future changes in climate in regions of the United States. This study examines warm-season precipitation from the nested regional climate simulations for the 1990s from the Climate of the 20th Century (20c3m) scenario and compare it against the 2090s from the SRES A2 scenario. Changes in frequency distribution and other characteristics of precipitation will be explored with a focus on shifts in the extremes.

Warm season deep convection is the main component of precipitation in many parts of the U.S., yet climate model simulations of warm-season, continental convection and associated precipitation do not compare well with observations. Much of the uncertainty involved in the prediction of precipitation under climate change scenarios is rooted in model resolution and the parameterizations used at those scales. At their coarse resolution, climate models have problems with topography, eddy processes, and sub-grid parameterizations, giving them little predictive ability at regional scales. Nested regional climate modeling helps address some of these issues and makes estimation of changes in regional precipitation more feasible. Since current climate models predict that extreme precipitation will change more than the mean, and any change in the hydrologic cycle would have a great impact in many sectors, especially at the extremes, it is important to provide plausible scenarios at resolutions finer than those currently available from GCMs to assess potential impacts from any changes.

Camacho, Jose
AEMET (Spanish Meteorological Agency)

Status of Health-Climate Related Applications at Spanish Meteorological Agency

Co-authors: D. Cano, A. Cadenas, G. Ballester, A. Mestre, E. Cuevas, M. López and A. Cansado (Spanish Meteorological Agency)

Spanish Met. Service has recently changed its administrative category to National Agency and became called AEMET (Agencia Estatal de Meteorología). In this new status, health and climate issues are one of its main duties in accordance with contract agreed with our institutional stakeholders.

Heat wave warnings have been issued in long time cooperation with health and civil protection authorities. Relative recent events (2003 European Heat Wave) have revealed the need of improvement in regions where do not have habitude to cope with high temperatures along several days or weeks. In relation with low temperatures, improvements have been focused at cold temperatures outbreaks because they are associated with increases in influenza cases and respiratory or coronary hospital urgencies. Comfort indexes based in well tested developments have been adopted. A single product including heat index and wind chill expressed as temperature is built. METAR reports provide a quick view of such combined index over Spain. Forecasts are based both at short term (High Resolution Limited Area Model) and medium term (European Centre for Medium range Weather Forecast) models.

Radiative transference models coupled with ECMWF outputs are used to delivered forecast on Ultraviolet radiation maximum Index (UVI). This is also complement with observed data from a network of 21 Ultraviolet-B broadband radiometers and 5 Brewer spectrophotometer sites that provided UVB daily totals and evolution. Strong cooperation with health authorities at national and regional level is being developed to make forecasts on conditions that enhance allergenic pollen concentrations.

Health impacts of atmospheric dust include the well-known aerosol-related respiratory and cardio-vascular problems and eye infections with the particularity that sensitive amounts of dust can also affect health in areas thousands of kilometres away form sources. The Northern Africa and the Mediterranean basin are regions specially affected by sand and dust storms. On the other hand meningococcal meningitis is an environmental disease whose spatial and seasonal distribution is readily described by climatic and environmental characteristics. Epidemics of meningococcal meningitis occur throughout sub-Saharan Africa, most frequently in an area, known as the ‘Meningitis Belt’ that stretches from the Sahelian zone of west Africa to the Horn of Africa. As a response to the interest, and with the support of Fourteenth World Meteorological Congress, the WMO secretariat launched the Sand and Dust Storm Warning, Advisory and Assessment System (SDS-WAS) in 2007 as a joint project of the World Weather Research Programme (WWRP) and the Global Atmospheric Watch (GAW) under the WMO Commission for Atmospheric Science. A WAS regional centre for Northern Africa, Middle East and Europe is being hosted by Spain and coordinated by AEMET.

Campbell, Heather
Oklahoma Climatological Survey
Southern Climate Impacts Planning Program (SCIPP)

Drought Policy in Oklahoma and Missouri

Drought is a rather universal natural hazard, yet when looking at state drought plans, each response to drought seems to differ. These differences extend even to definitions of what a drought is. Unlike tornadoes or hurricanes, it is difficult to detect onset and recovery during drought, much less assessing the extent of the damage. To help states and others cope with drought, organizations such as the National Drought Mitigation Center (NDMC) and National Integrated Drought Information System (NIDIS) have developed.

According to the NDMC, the number of states having drought plans has grown from only three in 1980 to 41 as of 2006. Many of these plans were developed during or immediately following a severe drought. The study that will be presented examines the process of drought plan development in two states - Oklahoma and Missouri. Major droughts were the impetus for planning activities in both cases.

The study design addresses what information was used in designing drought plans, how other plans and strategies influenced the state plan design, and the extent to which communication occurred between various state agencies, national centers such as NDMC, and the drought community. Findings from interviews are used to test different policy process models to determine similarities and differences between the two states. Implications of the research are that if a 'best' policy process model is identified, it may help NDMC and NIDIS work more effectively with other states in developing or revising their plans.

Chattopadhyay, Rajib
Indian Institute of Tropical Meteorology

A Non-Linear Bayesian Analog technique of Climate prediction: An Application to the Prediction of Monsoon Intraseasonal Oscillation

Co-authors: A.K. Sahai and B.N. Goswami (Indian Institute of Tropical Meteorology)

The prediction of weather and climate using various analog techniques were studied in various literatures in the past decades (Lorenz, 1969; Gutzlar and Shukla, 1984; Livezey and Barnston, 1988). The analog prediction of the Intraseasonal oscillation of the monsoon in the extended range shows a good prospect in a recent study (Goswami and Xavier, 2007; Chattopadhyay et al., 2008). The present effort is to highlight the use of Self Organizing Map (SOM algorithm, Kohenen, 1990) to construct the analogues of climates and its use in the monsoon Intraseasonal oscillation and thereby generalizing the use of this technique for operational purpose. The analogues are constructed from the information of non-linear evolution of six large-scale dynamical parameters from a large pool NCEP data in the past years. The large-scale dynamical parameters which are used in this study are shown to be convectively coupled with the intraseasonal evolution of rainfall pattern (Sahai and Chattopadhyay, 2006). The analogs of the present evolution of rainfall is being created from the past 50 years of data using the non linear clustering technique based on previously mentioned SOM algorithm. The SOM patterns are created by resolving the past data in 15x15 nodes as is being done in any artificial neural network technique. The said number of nodes is chosen after many permutations and experiments. The fourth pentad forecast verification is being done for the years 1999-2005. While the method is still being developed, it is clear that the success of the technique depends on the efficiency in peaking up the analogs and whether a similar analog exists in the past data or not. In some cases there may not be a proper analog available to represent the present data so that the fine scaled forecasting in the extended range is difficult. However the signature of the large-scale dynamical variable on the intraseasonal active and breaks in some years is noteworthy.

References:

Chattopadhyay, R., A. K. Sahai, and B. N. Goswami, 2008: Objective Identification of Nonlinear Convectively Coupled Phases of Monsoon Intraseasonal Oscillation: Implications for Prediction J. Atmos. Sci, 65, 1549-1569.

Gutzlar, D.S., and J. Shukla, 1984: Analogs of Wintertime 500mb height field. J. Atmos. Sci., 41, 177-189.

Kohenen, T., 1990: The self organizing map. Proc. IEEE .78(9), 1464-1480.

Livezey, R. E., and A. G. Barnston, 1988: An operational multifiels analog Prediction system for the United States seasonal temperatures. Part I: System design and wintertime experiments. J. Geophys. Res., 93, 10953-10974.

Lorenz, E. N., 1993: Atmospheric predictability as revealed by naturally occurring analogues. J. Atmos. Sci, 26, 636-646.

Sahai, A.k., and R. Chattopadhyay, An Objctive Study of Indian summer Monsoon Variability Using the Self Organizing Map Algorithms. IITM research report: IITM RR-113. (http://www.tropmet.res.in/~lip/Publication/RR-pdf/RR-113.pdf)

Ferguson, Daniel
Climate Assessment for the Southwest (CLIMAS)
University of Arizona

Evaluating Climate Assessment and Translational Science Efforts in the US Southwest: Lessons from a CLIMAS Pilot Evaluation Project

Co-authors: Anne Browning-Aiken (University of Arizona), Gregg Garfin (University of Arizona/Institute for Environment and Society/CLIMAS), Dan McDonald (University of Arizona, Pima County Cooperative Extension), Gigi Owen (University of Arizona/CLIMAS), Jennifer Rice (University of Arizona, Department of Geography and Regional Development), and Marta Stuart (University of Arizona, Yavapai County Cooperative Extension)

Instituted in 1998 as part of NOAA's Regional Integrated Sciences and Assessments program, the Climate Assessment for the Southwest (CLIMAS) program has conducted 10 years of use-inspired science aimed at improving the ability of decision makers in the southwestern United States to respond to climate variability and change. Beginning in the fall of 2007, we began a pilot evaluation project to understand better how the work done by CLIMAS is impacting the communities with whom we work. The evaluation approach combined qualitative and quantitative methods to understand stakeholder, partner, and collaborator perspectives on CLIMAS work. The primary goals of the project were to determine: (a) penetration of CLIMAS information to stakeholders, (b) the perceived salience, credibility, and legitimacy of CLIMAS research and outreach, and (c) changes in stakeholder attitudes, knowledge, and behavior as a result of partnerships and collaborative processes.

This presentation will focus on two aspects of this evaluation effort: 1) key results from the evaluation, with a particular emphasis on whom the program is reaching and examples of CLIMAS work successfully informing decision making processes; 2) insights and lessons learned from the evaluation process itself.

Ferguson, Daniel
Climate Assessment for the Southwest (CLIMAS)
University of Arizona

Fostering Collaboration and Information Exchange with New Technologies: Drought, Climate Change, Water Impacts, and Indigenous People

Co-authors: Gregg Garfin (University of Arizona/Institute for Environment and Society/CLIMAS), Sarah Trainor (University of Alaska Fairbanks/Alaska Center for Climate Assessment and Policy), Cheryl Anderson (University of Hawaii/Pacific RISA), Umerang Johannes (University of Hawaii), La'Ona deWilde (University of Alaska Fairbanks), and Gigi Owen (University of Arizona/CLIMAS)

Natural resource managers in Native American communities throughout North America and local and indigenous communities in the Pacific Islands have expressed concern about how drought can initiate a cascade of impacts that affect water supplies, water quality, food production, and forest health. With global temperatures on the rise, the impact of drought on water supplies and ecosystems can only be expected to increase.

This poster will describe an ongoing project that involves engaging tribal and indigenous decision makers and resource managers from Alaska, the US Southwest, and the Pacific Islands as well as climate scientists from these regions in three cross-region dialogues using video conferencing technology. Our chief goals are to: (a) facilitate networking and communication among Native natural resource managers across these diverse regions, (b) identify approaches, tools, and techniques to improve drought awareness, planning, preparedness, and response in each region and (c) improve the ability of the National Integrated Drought Information System (NIDIS) to address the information needs of underserved populations by strengthening communication, and prioritizing research and decision support needs.

These dialogues allow participants to hear about water stress and climate change in other regions and how others are responding and strategizing in response to these issues. Some drought impacts noted by participants include: increased occurrence of Hanta virus and plague, water shortages, increased salt concentrations in water supplies and in plant root zones, decreased agriculture and rangeland production, dust pollution and dune migration (Southwest); increased wildfires, in-migration of new insect-pests and forest mortality, declines in wildlife populations and changes in migration patterns, increases in fish parasites, and cessation of barge transport of critical supplies, such as winter fuel oil, when streamflows are low (Alaska); critical water shortages and water rationing, reduced agricultural irrigation allocations and decreased production, decreased cattle production, and wildfires (Pacific Islands). Participants noted that it is not useful to distinguish between drought and climate change impacts. In fact, they recommend an integrated approach to addressing drought, climate change, and environmental issues, and they emphasized that online decision support tools, data and information on these topics must be comprehensive and integrated in order to serve indigenous and Native American populations. They recommend these integrated approaches to all federal agencies, which suggests that their needs will best be met by integrated climate and environmental services, such as those being pioneered by NIDIS, but with a much greater level of integration and cooperation between agencies.

Foster, Josh
Center for Clean Air Policy (CCAP)

The Urban Leaders Adaptation Initiative: Climate Resilient Local Governments

Local governments, the first responders to public health, safety and environmental hazards, must act now to lessen vulnerabilities to climate change. They must plan for and invest in "adapting" to inevitable impacts such as flood, fire, and draught that will occur notwithstanding best efforts to mitigate climate change.

CCAP's Urban Leaders Adaptation Initiative is developing a framework for informed decision making on climate adaptation. Looking ahead to projected climate impacts and 'back casting' can identify what is needed now to both reduce greenhouse gas emissions and build local resiliency to climate change.

CCAP's partnership with King County (WA), Chicago, Los Angeles, Miami-Dade County (FL), Milwaukee, Nassau County (NY), Phoenix, San Francisco, and Toronto is advancing policy discussions to ensure that state and local governments consider climate change when making decisions about infrastructure, transportation, land use, and resource management.

Through the Initiative, local leaders will incorporate climate change into daily urban management and planning activities, proactively engage city and county managers and the public in developing solutions, and build community resilience.

Determining appropriate adaptation strategies for each jurisdiction requires Asking the Climate Question: "How does what we are doing increase our resilience to climate change?" Over three years, UL will design and implement specific adaptation plans, policies and 'catalytic' projects, collect and disseminate "best practices," and participate in framing national climate policy discussions.

In the coming years, policy-makers will have to consider climate change in major infrastructure development decisions. If they are to be successful and have the resources they need, national climate change policy and emerging legislation will have to support these communities. UL will equip CCAP partners with the knowledge and tools to start planning and implementing adaptation measures. Drawing on state, local and national policy experts, it will recommend comprehensive actions that will enable the federal government to support local resiliency efforts.

CCAP has identified three core principles for national climate adaptation policy:

1. National climate policy should support state and local adaptation planning and implementation, such as through use of cap-and-trade allowance auction proceeds;
2. Federal agencies should provide adaptation assistance to state and local governments, including regional impact assessments, downscaled climate model data, updated flood maps, planning tools, drought early warning, and implementation guidance; and
3. A national climate service and extension network needs to be established to aid local governments implementing resilience measures in collaboration with universities, companies and technical experts around the country.

Fraisse, Clyde
University of Florida

A Disease Forecast System for Strawberries as a Tool on Agroclimate

Co-authors: Willingthon Pavan and Natalia Peres

Strawberries are one of the most valuable crops in Florida. The state produces about 16 million flats of strawberries every year, which represents 15% of nation's berries and virtually all the berries grown during the winter. In 2004, over 7,000 acres were devoted to strawberries with an estimated return to the grower approaching to $200 million. The high value of the crop often compels growers to protect their profits by applying fungicides on a weekly schedule, mainly for control of Anthracnose and Botrytis fruit rot, from December through March.

These are the most important diseases for production of annual strawberries in central Florida and worldwide. Predictive models for Anthracnose fruit rot and Botrytis fruit rot have been adapted and validated to the local conditions. These models were embedded in a web-based tool developed for use by growers to schedule their fungicide applications. The developed strawberry disease forecast management tool has been delivered through the SECC AgroClimate web-based information systems. AgroClimate is maintained by the State of Florida Cooperative Extension Service and is updated and maintained periodically to ensure the relevance of the information and decision support tools contained in the system.

The system uses recent and current weather conditions data collected by the Florida Automated Weather Network (FAWN - http://fawn.ifas.ufl.edu) and short term weather forecast obtained from the National Weather Service – National Digital Forecast Database (NDFD - http://www.nws.noaa.gov/ndfd). Seasonal climate forecast based on El Niño Southern Oscillation (ENSO) phases is also used to provide growers with expected disease pressure levels. The system was developed using different technologies, on server and client side. On the server-side we used R statistical language (models), PHP (dynamic pages) and MySQL database. On the client-side we used Google Maps API (map control), JavaScript and Ajax (user control and asynchronous connection with the server), and HTML with CSS (layout).

The implementation of this internet-based forecasting system to predict anthracnose and Botrytis fruit rots enable growers to easily access the information necessary for them to decide on the need for a fungicide application. The benefits of such a tool is that growers can apply fungicides only when conditions are favorable for disease development, thus reducing the number of applications and production costs without compromising disease control.

Garfin, Gregg
IES, University of Arizona

A Multi-Scale Hydroclimatic Index for Monitoring Drought in the Semiarid West

Co-authors: Andrew Ellis (Arizona State University) and Melanie Lenart (University of Arizona)

Efforts to monitor and portray drought status are hampered by reliance on indices that contain regional biases and limited relationship to the multiple dimensions of drought. Many decision-makers are loath to take management actions based on drought status information derived from complex and arcane drought indices. Use of the Standardized Precipitation Index, a solution preferred by many climatologists, ignores half of the hydrologic equation – the temperature-driven climatic demand for water. This is a critical problem in the Southwest, where evaporative loss dominates the hydrologic budget during summer; thus, despite comparable seasonal totals, summer precipitation is rendered less effective than winter precipitation. We seek to enhance the array of drought monitoring tools for the semiarid Southwest by making available an easily understood hydroclimatic index (HI). With the HI, we define drought as the difference between supply, precipitation (P), and demand, potential evapotranspiration (PE). We estimate the HI at fine spatial scales by using PRISM temperature and precipitation, and portray drought status in map and time series formats. We convened focus group sessions with Arizona stakeholders, in order to introduce them to the HI and to garner their qualitative feedback. We found that the HI generally accords with their experiences of drought, flood, and ecosystem impacts. In particular, the HI PE component appears to improve portrayal of ecosystem status and trends in reservoir status. In this presentation we will show the results of qualitative and quantitative validation exercises.

Garfin, Gregg
IES, University of Arizona

Improving Information Flows to Enhance Drought and Climate Change Resilience in Northern Mexico

Co-authors: Ashley Coles (University of Arizona), Jamie McEvoy (University of Arizona), Kate Sammler (University of Arizona), Robert Varady (University of Arizona), Margaret Wilder (University of Arizona), Chris Scott (University of Arizona), Tereza Cavazos (CICESE), Andrea Ray (Western Water Assessment), David Gochis (NCAR), Nicolas Pineda (Colegio de Sonora), Luis Farfan (CICESE), and Rolando Diaz (University of Arizona)

We report on preliminary results from two coordinated initiatives to assess climate vulnerabilities and improve climate information dissemination in the U.S.-Mexico Border Region. The projects focus on a transect of paired urban and rural areas extending from Tucson and Sierra Vista, Arizona to Hermosillo and Puerto Penasco, Sonora. Vulnerability assessments, consisting of literature review, field studies and interviews, and discussion-focused workshops examine (a) exposure to climate risks, such as tropical storms, monsoon precipitation, and drought, (b) urban and agricultural water management policies and practices, (c) and emergency preparedness practices. We report on the dissemination of an experimental quarterly climate information and impacts newsletter, stakeholder information needs assessments, and prospects for experimental online climate briefings and webcasts. Findings from an initial workshop, conducted in November 2008, suggest that stakeholders desire more information about desertification, forest fires, and tropical storms. The phenomena that stakeholders identified as representing large risks for society include early and late freezes, high winds and other extreme events associated with storms, and drought. The participants noted that the impacts of risks depend in largely upon perception of risk, distribution of vulnerability and exposure to the risk, and whether the impacts are felt in the long- or short-term. Workshop participants recommended the following for reducing climate-related risk: public education, the development of a culture of information use among the public, enhancing existing infrastructure and to increase the efficiency of water delivery systems and to provide greater protection for vulnerable populations and crops. Participants indicated that it is useful to have climate information from different sources in one location, and that the climate newsletter has potential to support decision-makers. To improve newsletter effectiveness, they recommended higher resolution data and instructions for how to alleviate or prevent losses related to the parameters and risks that are forecast in the publication (e.g., increased temperatures, precipitation variations, seasonal tropical storm forecasts). All stakeholders showed a strong interest in a hydroclimatic information system that consolidates official and mesonet data, forecasts, impact information, and response options. Agricultural stakeholders expressed interest in enhanced online decision support, based on ENSO phase and/or intra-seasonal factors.

Garfin, Gregg
IES, University of Arizona

Reducing Drought Vulnerability Through An Urban Landscape Decision Tool

Co-authors: Rolston St. Hilaire (New Mexico State University), Clyde Fraisse (University of Florida/SECC), Merrill Bean (New Mexico State University), Salman Daifallah Al-Kofahi (New Mexico State University), Malik Ghazi Al-Ajlouni (New Mexico State University), and Ellen Lay (University of Arizona)

The total economic contribution of the green industry to New Mexico's economy during 2004-2005 was $1.39 billion, with 52% resulting from activity in urban landscapes, parks, and open spaces. Rapid population growth and increased tourism is likely to increase the relative contribution of the green sector to the state's economy. In Albuquerque, New Mexico's largest city, mandatory conservation efforts were most recently invoked in 2006, when the city declared a "Drought Watch" that limited outdoor watering to no more than three days per week. Although this strategy has the potential to conserve water, advances in technology and administrative reforms allow more dynamic means of residential water conservation during drought, such as individualized water budgets that are based on landscape type, climate variability and demand forecasts, and price indicators. We report on a project that aims to reduce the drought vulnerability of New Mexico's urban agricultural sector through the development of an urban agricultural component for the AgroClimate decision-support tool. The AgroClimate urban landscape drought module provides realistic estimates of urban landscape water budgets and potential water savings under different outdoor water management strategies. A climate needs assessment, administered to New Mexico Extension agents and specialists, revealed a 62% likelihood that urban agriculturists would use climate information to aid decisions. Furthermore, 76% of the agents believe that information on urban agriculture and home horticulture is highly relevant to their county. In the first part of our project, a pilot study in Las Cruces, New Mexico, we have classified urban landscapes into distinct types, based on quantitative factors such as percentage lawn area and the ratio of softscape (e.g., trees and shrubs) to hardscape (e.g., pavement and patios). We will use climate information to estimate urban landscape water budgets for the different landscape types and estimate landscape performance under changing drought scenarios. A similar study will be performed for Albuquerque. These data form the backbone for a website map interface that allows users to identify their neighborhood and landscape type. Some custom adjustments can be made for time of year, and other required factors. Drought water budget and landscape performance calculations can be tied to urban drought plans. Our goal is to provide science-based landscape drought impacts and trigger levels. Our key partner is the New Mexico Cooperative Extension Service. Key stakeholders include the New Mexico Water Task Force, the New Mexico Drought Task Force, and urban homeowners and horticulturalists.

Guentchev, Galina
UCAR CLIVAR CPAPP

Homogeneity Analysis of Hamlet and Lettenmaier (2005) and Daly et al. (1994) Precipitation Gridded Data Sets for the Colorado River Basin

Co-authors: Joseph Barsugli (CIRES, University of Colorado Boulder) and Jon Eischeid (CIRES, University of Colorado Boulder)

A long-term climate change analysis requires the homogeneity of the data to be evaluated. Homogeneous climate data reflects only the weather and climate variations. Inhomogeneity in gridded data could result from the use in the gridding process of data from inhomogeneous stations or could be introduced during the gridding process itself. Two gridded data sets based on observed precipitation were considered in this analysis: the data set developed by Maurer et al. (2002) and later updated and extended by Hamlet and Lettenmaier (2005) (HL hereafter), and the Daly et al. (1994) Precipitation Regression on Independent Slopes Method (PRISM hereafter) data set. These data sets have been used in downscaling climate model output. Four tests were used in the homogeneity testing: the Alexandersson Standard Normal Homogeneity test (SNHT) for a single break, the Buishand range test, the Pettit test, and the Von Neumann ratio test (see Wijngaard et al. 2003 for a description of the tests).

The homogeneity of the individual grid-points, as well as of sub-regions (as defined by the USGS hydrological unit classification) within the Colorado River Basin from the HL and PRISM data sets for the water years for the 10/1949 – 09/1999 and the 10/1915-09/2006 periods was tested. The results from the homogeneity tests were used to classify the data series in terms of data quality.

Results and conclusions:

- Almost all of the grid points from the PRISM data set and most of the grid points from the HL data set within the sub-regions that generate the most runoff are classified as "useful" for the period 1950-1999. The results indicate a 1977-1978 discontinuity in about 12 (PRISM) -22 (HL) % of the time series.
- The longer period (1916-2006) is characterized by greater grid point homogeneity for the PRISM dataset (96% of the grid point series were classified as "useful") compared to the HL data set.
- The discontinuity for the longer period is still 1977 for the "doubtful" and "suspect" grid point series from the PRISM data set and around 1949-1950 for the HL data set.
- Potential contributors to the detected inhomogeneities in both data sets could be: a) Changes in the number of available stations involved in the gridding process throughout the period; b) Inclusion of inhomogeneous stations series in the gridding process; or c) Ability of these absolute tests to identify shifts in the series resulting from natural variability (WMO CCI, 2003).

Guido, Zack
Climate Assessment for the Southwest (CLIMAS)
University of Arizona

The Effect of ENSO Events on Freeze Occurrences in New Mexico: Supporting Better Resource Management Decisions

Co-author: Gregg Garfin (University of Arizona)

After pecan trees in New Mexico burst their buds, an unexpected freeze can decimate the crop. To protect the buds, some farmers light fires to stave off deep freezes with marginal success. Chilies, alfalfa, and other vegetables are also susceptible to freezes. In many counties in New Mexico, significant economic losses and social hardship have accompanied minimum temperatures that destroy crops.

In recent interviews conducted by researchers working with the Climate Assessment for the Southwest (CLIMAS), many New Mexican farmers stated that having probability forecasts for the date of the first and last freeze would be useful in making decisions, such as when to plant, what varieties to grow, and how many workers should be staffed during the early season. Many of these same farmers were aware that El Nino-Southern Oscillation (ENSO) phases impact the weather in New Mexico, but probabilistic analyzes of the timing of future freezes during ENSO phases is not available.

To help provide resource managers with this vital information, CLIMAS is investigating the relation between ENSO events and the first and last occurrences of cold temperatures that harm several crops. CLIMAS is analyzing the minimum daily temperature for the months October through March at 110 COOP weather stations in New Mexico. Part of this study will identify data inconsistencies in the stations, such as the temperature effects of moving a weather station or a change in the time of measurement. CLIMAS will generate probability maps of the occurrence of the first and last dates when threshold temperatures are breached for each of the three ENSO phases—El Niño, La Niña, and Neutral. The maps will be posted on an interactive website that contains information on climate and agriculture that help resource managers understand probable outcomes under forecast climate conditions. The website will be modeled after the Southeast Climate Consortium's AgroClimate website: http://agroclimate.org.

This study also investigates other factors that may affect minimum winter temperatures, such as the Pacific Decadal Oscillation and the recent warming attributed to anthropogenic emissions of greenhouse gases.

Halpert, Mike
NOAA Climate Prediction Center

Strategy for Developing Climate Forecast Products in Cooperation with Partners

The CPC plans to develop collaborative partnerships that accelerate the development and delivery of useful climate forecast products to enhance the value of NOAA's climate services. The CPC-RISA program has been an excellent example of a partnership between a national operational federal service center (CPC) and regional intermediaries (the RISAs). As resources permit, CPC would like to expand these collaborations to other interested groups such as the Applied Research Centers (ARCs), the Regional Climate Centers (RCCs), and the Climate Services Program Managers (CSPMs) for example.

The CPC will be organizing two Climate Forecast Product Teams that will function to accelerate the development of climate forecast products in collaboration with these partners. The "Climate Products Outreach Team" (CPOT) will engage our partners in the research and applications community to accelerate the development and delivery of climate forecast products that meet user needs. The primary role of the CPOT will be to develop recommendations for product improvements or new product development that will be passed to the second team, the "Climate Products Implementation Team" (CPIT). The CPIT will consist of both NOAA and non-NOAA members and will review and rank recommendations made by the CPOT for the development of new and improved climate forecast products. The CPIT will provide this input to the CPC management who will make the final decisions concerning implementation. The CPIT will develop objective guidelines for the ranking process which will be subject to internal and external operational and resource constraints.

Hartmann, Holly
Arid Lands Information Center
University of Arizona

Collaborative Development of Decision Support Tools for Climate Applications

Co-author: Ellen Lay (Arid Lands Information Center, University of Arizona)

Within the climate applications community, many research groups are developing decision support tools for use by a wide variety of stakeholders. Increasingly, there is interest in transferring tools developed in one region to another, or extending tools for use by new sectors, with an eye toward ultimately supporting national climate services. Issues of complexity and inefficiency in handling software modifications quickly arise as each transfer to another institution creates a new set of computer code that must be maintained separately and coordinated with any software updates from the original developer or others. Further, as the applications community develops new analytical capabilities in response to stakeholder needs, each research group faces the prospect of having to create and support a comprehensive basic software infrastructure to create even a simple web application. Collectively, the duplication of effort is tremendous and costly, as many tools perform similar tasks (e.g., subsetting data to specific time periods or spatial domains, handling user registration and system security). Myriad overlapping tools also create problems for the agencies expected to ultimately house the tools for long-term operation, as well as stakeholders trying to navigate and conceptually integrate multiple tools with each having a different look and feel.

Collaborative software development (CSD) is an information technology (IT) that offers a path forward, by allowing many groups to work with the same computer code base, with each contributing software modifications or extensions, whether small or large. The climate modeling community has made some use of CSD, but the climate applications community is just beginning to explore the potential for increasing the transferability and scalability of decision support tools. This presentation is designed for the research community rather than information technologists. We explain CSD processes and tools so researchers can communicate effectively with IT specialists, and begin to assess the potential for using CSD in their own projects and in collaboration with others. In particular, we review version control systems (e.g., CVS and Subversion), problem and task tracking systems (e.g., Bugzilla), and example software applications useful in a climate applications context. CSD is not a panacea, however. Success depends on clear management structures that address priority setting, quality review, and recovery from application failures, as well as commitment to consistently follow established procedures.

Hartmann, Holly
Arid Lands Information Center
University of Arizona

Using Web Services to Integrate Climate Applications

Co-author: Ellen Lay (Arid Lands Information Center, University of Arizona)

At the 2008 CPAS Workshop, participants requested an explanation of web services technology that would help the climate applications research community assess the potential of web services in development of decision support tools. Presently, the primary users of the World Wide Web are people, i.e., humans using web browsers, graphical user interfaces (GUIs), and media players, among others, to access documents, data, and analytical tools. But the Web has significantly expanded in scope, allowing the same type of communications to occur between computer applications, one program to another. "Web services" is the information technology (IT) which makes this possible, by substantially increasing the scale and efficiency of information exchange and development of flexible web applications. Web services can perform functions from simple requests to complex chains of analytical processes. More importantly, web services allows the internet to move from a "human-centric web", to an "application-centric web", and provides a vision for the future of an "automated web", in which distributed computing and interconnected applications become ubiquitous. This presentation, designed for the research community rather than information technologists, explains how web services work, and how they differ from other web technologies, e.g., the HTML behind most webpages and the FTP used for file transfers. Terms like SOAP, WSDL, XML, and HTTP are explained so that researchers can communicate effectively with IT specialists. Discussion of web services used in current climate-relevant applications will allow researchers to begin to assess the potential for using web services in supporting their own decision tools or connecting with applications of other groups.

Hernandez, Jose
University of Florida
Agricultural and Biological Engineering Department

Decadal Land Use Change and Regional climate modeling Experiments Applied to Water Management: West Central Florida Case study

Co-authors: Syewoon Hwang (University of Florida), Guillermo Baigorria (University of Florida), Keith Ingram (University of Florida), James Jones (University of Florida), and Wendy Graham (University of Florida)

West Central Florida, particularly Tampa bay region, has been rapidly developed over a recent few decades with major conversion from agriculture to urban land surface categories. Such land coverage alterations have an impact on surface energy exchange and temperatures, making noticeable contrasting environmental conditions between urban and surrounding areas. Correcting land use (LU) on hindcast simulations, and updating LU distribution categories in climate models will allow better predictions on hydrological conditions. Such analytically derived information is useful for water and energy management agencies and decision making in the studied area, where LU decadal change is likely attributed to increasing population and industrial development. In order to study the impact of regional land use change on climate conditions, we are investigating changes in precipitation and lower atmosphere circulation through mesoscale climate modeling simulations. We are combining sensibility analysis and statistical (spatial and temporal) methodologies to survey such impacts during a decadal study period, 1993-2003 in West-Central Florida. Model domains are set at 9 km, 3 km and 1 km resolutions under different physical configurations with a fine description in the lower atmospheric. We inspect changes in the patterns of atmospheric circulation close to the land surface and the energy budget at daily, seasonal and decadal scale. Model validation is carried out using hourly meteorological data. Particular attention is given to stations surrounded by urban areas exhibiting major land management changes during the decadal period, like those on the Gulf of Mexico coastal side, as well as stations on the Atlantic coast. Temperature, precipitation and wind are studied for all stations. In coastal areas, land-sea breeze processes and urban effects are surveyed. Observations reveal more frequent precipitation in Tampa Bay than other areas while the model tends to follow the observed spatial pattern. Decadal land surface change effects are difficult to determine. Under the coastal urban areas included in this study, the atmospheric vertical structure is more complex than in inland counterparts and land-sea breeze processes in general dominates their climate variability.

Higgins, Wayne
NOAA Climate Prediction Center

CPC Products: Present and Future

A strategy for improving CPC climate prediction products by engaging the external community is presented. The strategy aims to address several key questions, including:

- Who are the users of the information provided (both internal and external)?
- How do we know if the support we provide is having an impact on decision making?

CPC is working to improve the product suite in two important ways:

- Improve the skill of official outlooks, and
- Expand / improve the product mix and presentation.

We are asking help from the CPAS community primarily in the second area. The presentation will include an overview of CPC climate prediction products and a summary of CPC climate prediction activities, with emphasis on areas where the CPAS community can help. The presentation will conclude with a set of general questions that are intended to set the stage for a panel discussion aimed at developing actions for partnerships between CPC and external organizations (e.g. RISA's, ARCs, RCCs, SCs, academia) to enhance the CPC product suite.

Hill, Harvey
Agriculture and Agri-Food Canada

Getting the Balance Between Variability and Long Term Climate Change and How it Relates to Developing an Adaptation Program for the Canadian Agriculture Sector

Agriculture is highly sensitive to intra-seasonal, seasonal, decadal and long term climate trends and events. Because of its complex combination of socio-economic and environmental characteristics applications of climate information to agricultural decision-making must find a way to integrate climate information at a variety of spatial and temporal scales. This presentation will describe the strategy and tangible applications that have been developed by the National Agroclimate Information Service with its partners to address this challenge.

Holthaus, Eric
International Research Institute for Climate and Society
The Earth Institute at Columbia University

Climate Impact Indices for Drought Risk Management, Focusing on Index Insurance and the Millennium Villages Project sites in Africa

Co-authors: Asher Siebert (International Research Institute for Climate and Society), M. Neil Ward (International Research Institute for Climate and Society), Walter Baethgen (International Research Institute for Climate and Society), Molly Brown (NASA-Goddard Space Flight Center), Daniel Osgood (International Research Institute for Climate and Society), and Matayo Indeje (International Research Institute for Climate and Society)

We report work that establishes indices to measure the climate-induced drought risk for agriculture at the Millennium Villages Project sites in Sub-Saharan Africa. We compare our results for locations that span across 10 different agroecological zones. This work was motivated to enhance the management of droughts as part of an integrated set of interventions to sustainably achieve the Millennium Development Goals in rural Africa. A focus of the reported work is on the application of indices for drought index insurance. In the context of drought index insurance, we also discuss the implications of seasonal predictability and changes in the background climate state, due to natural multidecadal variability and global climate change.

The effectiveness of a range of real-time in situ and remotely sensed drought indices is examined. The focus is on the reliable detection of drought impacts for given event thresholds in extreme years. The quantitative degree of match with crop yield/production data is used to evaluate the ability of drought indices to detect drought impacts. Such results provide insights on the practicality of drought index insurance given the existing remotely sensed datasets and in situ observational networks. Simple quantitative evaluation measures such as correlation analysis, are supplemented with methods that quantify the degree of match in the threshold categories, such as the Gerrity skill score. The assessment of methods provides a general convergence of evidence, suggesting that through careful processing of remotely sensed and in situ data, reliable real-time detection of drought impacts for the purposes discussed here is feasible now, with further improvements anticipated as longer records of more sophisticated remotely sensed information become available.

Hu, Qi S.
University of Nebraska-Lincoln

Accuracy of the Medium Range Precipitation Predictions in the U.S. and Their Use in Agricultural Decision-Making

Co-author: Kari Skaggs (University of Nebraska-Lincoln)

Farmers participating focus groups organized in several eastern Nebraska counties have indicated that the forecast of 6 to 10 day accumulated precipitation is the most useful forecast information for their major growing season decisions, which include irrigation scheduling, scheduling for applications of pesticides and herbicides, as well as harvesting. Meanwhile, farmers also indicated a major obstacle that hindered their use of this information, i.e., its accuracy and associated uncertainty. There has been no quantitative assessment of this and other short- and medium-range forecasts made by CPC in a format that can be easily understood by farmers. To provide such a measure for the purpose of improving farmer's use of the forecasts, the accuracy of 6-10 day accumulated precipitation forecasts for the U.S. was evaluated by comparisons between the forecasted and observed precipitation. The results are mixed; some regions show improvement, some show stagnant, and still some show deteriorating in accuracy of this forecast in the past 6 years. Analysis of these changes in forecast accuracy indicates that the climate variations in different regions may have affected the effort of improving the accuracy of the forecasts. The disturbing fact of deteriorating forecast accuracy in some regions may make the forecast use in farming decision-making even more challenging.

James, Tom
Institute of Public Affairs
University of Oklahoma

Enhancing Climate Literacy

Co-authors: Mark Shafer and Nicole Giuliano (Oklahoma Climatological Survey, University of Oklahoma)

Many local and regional planners are not aware of the causes of climate change and variability or where to find information about climate that may be integrated into their operations. Brief presentations at workshops do not allow sufficient time to relay complex information; more than an hour or two is needed. More formal outreach training activities tend to be oriented toward multi-day workshops. While these provide much more detail and equip decision-makers well for using climate information, the investment of time for many managers is too great.

To balance these competing forces, the Oklahoma Climatological Survey (OCS) developed a one-day "Climate Training" workshop focused on fundamentals of climate and weather, sources of climate information, climate change, and special topics such as drought and hazards. The project is funded by the NOAA Sector Applications Research Program (SARP). The workshops build upon the successful multi-day training courses used by OCS' K-12 and public safety outreach programs, with information distilled to a level commensurate with a one-day course.

Each of the workshops includes an evaluation component. At each workshop, participants are asked to complete a pre-test and a post-test to assess learning during the training. Four to six months after each workshop, participants are contacted to gather information about how information from the workshops has affected advice they give to agricultural producers. This enables an assessment not only of direct changes in knowledge, but a qualitative assessment of changes in practices that may have some relationship to the long-term goals of mitigating climate-related impacts. Results from the series of six workshops and preliminary evaluation findings will be presented.

Kimble, Chris
National Weather Service
Amarillo Weather Forecast Office

The Return of the Dust Bowl to the Southern High Plains?

With the early 2008 drought in the Western Oklahoma Panhandle and Northwestern Texas Panhandle, there have been many comparisons of the current dry period with the infamous Dust Bowl of the 1930s. While it is difficult to predict the future, it is possible to compare the current dry period with that of the 1930s. Although the year 2008 began extremely dry, with less than 2.5 inches of rain falling in the first half of the year in some places, the overall dryness of this decade has been much less intense and much less widespread than the Dust Bowl of the 1930s. Since the year 2000 parts of the High Plains have been abnormally dry, most notably the Northwestern Texas Panhandle and the Western Oklahoma Panhandle (along with adjacent areas of Northeast New Mexico). The cumulative effect of the prolonged dryness has impacted not only crops and grasslands, but also area lakes and reservoirs including Lake Meredith. This poster will compare the current dry period with that of the 1930s in the Southern High Plains.

Konrad, Charles E. II
Southeast Regional Climate Center

The Clustering of Extreme Weather Events with Respect to Time and Their Relationship with the Planetary Scale Circulation

Co-authors: Peter J. Robinson (SRCC), Christopher M. Fuhrmann (SRCC), and Gretchen S. Carlson (SRCC)

A very small portion of weather events are responsible for the vast majority of impacts to human and environmental systems. These extreme weather events show much unevenness in terms of their occurrence with respect to time. Long periods of quiescent weather are found that are punctuated by short periods in which extreme weather events are clustered. For some types of extreme weather, such as hurricane landfalls and arctic outbreaks, these temporal clusters show some relationship with the cycles observed in the planetary scale circulation. In this study, the temporal clustering of various types of extreme events are identified and related to anomalies in the planetary scale circulation as summarized by circulation indices. Eight types of extreme weather are investigated for the period: 1950-2007 across the southeastern U.S., including arctic outbreaks, heat waves, dry periods, heavy rainfall, severe thunderstorms, landfalling tropical cyclones, ice storms and snowstorms. Automated computer routines are developed to identify various characteristics of their temporal distribution. This includes the identification of temporal clusters across several time scales (1, 2, 5, and 10 years) as well as the most extended period in which no events are observed. Relationships are then identified between these exceptional periods and the nature of the large scale circulation as assessed from the following standardized indices: ENSO, the North Atlantic, Arctic and Pacific Decadal Oscillations and the Pacific-North American pattern. Preliminary results indicate varying degrees of temporal clustering across the different event types as well as widely varying relationships with the planetary scale circulation indices.

L'Heureux, Michelle
NOAA Climate Prediction Center

ENSO Alert System for Monitoring and Assessing the ENSO-Cycle

Co-authors: Wayne Higgins, Mike Halpert, and Vern Kousky (NOAA/NCEP/Climate Prediction Center)

Starting in February 2009, the ENSO Alert System will become operational and will be issued as part of NOAA Climate Prediction Center's (CPC) monthly ENSO Diagnostic Discussion and Climate Diagnostics Bulletin. The ENSO Alert System will be used to more succinctly describe the onset and status of ENSO in order to increase the understanding of ENSO among federal and state agencies, academia, the private sector, and the general public. The ENSO Alert System consists of El Nino or La Nina watches and advisories. Watches will be issued when the environment in the equatorial Pacific is favorable for the development of El Nino or La Nina conditions within the next three months. Advisories will be issued when El Nino or La Nina conditions are observed and expected to continue. CPC relies on its partnerships with the external community to gather feedback on the response to and impact of the ENSO Alert System.

Lay, Ellen
Arid Lands Information Center
University of Arizona

Using Web Services to Integrate Climate Applications

Co-author: Holly Hartmann (Arid Lands Information Center, University of Arizona)

At the 2008 CPAS Workshop, participants requested an explanation of web services technology that would help the climate applications research community assess the potential of web services in development of decision support tools. Presently, the primary users of the World Wide Web are people, i.e., humans using web browsers, graphical user interfaces (GUIs), and media players, among others, to access documents, data, and analytical tools. But the Web has significantly expanded in scope, allowing the same type of communications to occur between computer applications, one program to another. "Web services" is the information technology (IT) which makes this possible, by substantially increasing the scale and efficiency of information exchange and development of flexible web applications. Web services can perform functions from simple requests to complex chains of analytical processes. More importantly, web services allows the internet to move from a "human-centric web", to an "application-centric web", and provides a vision for the future of an "automated web", in which distributed computing and interconnected applications become ubiquitous. This presentation, designed for the research community rather than information technologists, explains how web services work, and how they differ from other web technologies, e.g., the HTML behind most webpages and the FTP used for file transfers. Terms like SOAP, WSDL, XML, and HTTP are explained so that researchers can communicate effectively with IT specialists. Discussion of web services used in current climate-relevant applications will allow researchers to begin to assess the potential for using web services in supporting their own decision tools or connecting with applications of other groups.

Littell, Jeremy
University of Washington Climate Impacts Group

Developing Hydroclimatic Reconstructions for Water Resources Management in the Pacific Northwest

Co-authors: Alan F. Hamlet and Nathan J. Mantua (University of Washington Climate Impacts Group)

Water resource managers in the Pacific Northwest face a number of challenges including growing population (especially urban), emerging water issues such as the protection and restoration of endangered salmon populations, natural climate variability (particularly drought and decadal precipitation variability), and climatic change. The instrumental record contains only a subset of the range of natural variability possible, and longer records of streamflows based on tree-ring chronologies provide an important avenue for providing an improved understanding of regional hydroclimate uncertainty. Furthermore, a growing body of evidence demonstrates that climate in the western U.S has changed markedly in the 20th century, and there is a need to relate the droughts in the past to current climatic conditions (which in particular are now believed to be systematically warmer than in the early part of the instrumental record). By combining tree-ring chronologies with hydrologic simulations associated with systematically warmer temperatures expected for the 21st century, improved projections of future drought conditions will be produced. Water managers in the PNW have expressed interest in developing long-term hydrologic reconstructions in order to better anticipate the range of future climate conditions and their impacts on water resources. Stakeholders include members of several water-dependent industries including municipal, hydropower, salmon fisheries, and irrigation-based agriculture. The multiple-use nature of water resources in the western PNW and the communication between the Climate Impacts Group (CIG) and water managers provide an opportunity to explore applications of reconstructed hydroclimate as a tool for understanding the future nature of PNW droughts. In this study we focus on collaboration with water providers to integrate our understanding of climate variability in decision-making and climate change planning. This project consists of: (1) development of a network of tree-ring chronologies sensitive to both winter and summer precipitation, (2) streamflow reconstructions for gages of importance to water resource managers; and (3) a vulnerability assessment of streamflow supply given changes in future mean climate and past variability. In this paper, we report on progress in dendroclimatic reconstructions and the relationship between tree-ring chronologies and hydrologic model output.

Lowrey, Jessica
Western Water Assessment
University of Colorado

Evaluation of the Intermountain West Climate Summary: Lessons for Communicating Climate Information

Co-authors: Kristen Averyt, Julie Malmberg, Andrea Ray, and Jenifer Martin (Western Water Assessment/NOAA/University of Colorado)

The Western Water Assessment (WWA) produces the Intermountain West Climate Summary (IWCS) eight times per year as an outreach tool to increase our stakeholders' climate literacy. Our primary audience is municipal, agricultural, and federal water managers in Colorado, Wyoming and Utah. After four years of production, we have conducted a survey to evaluate the IWCS and assess how our stakeholders are both using it and learning from it. Our goal is to improve the IWCS as a communication tool and provide guidance to NOAA about how best to present climate information to regional water resource decision makers.

WWA uses the IWCS as a tool to educate our stakeholders about interpreting climate information and forecasts and about how climate affects the water supplies they manage. The IWCS contains annotated graphics and maps showing current and forecasts of precipitation, temperature, snowpack, streamflow and water supply conditions, as well as climate, drought and ENSO outlooks. We also include a feature article summarizing current research related to climate at water resources in the west, and a short "focus page" that describes a climate service and how to interpret the available information.

We used an internet-based survey of about 35 questions to evaluate the utility of the climate information, the quality text annotating the graphics, and level of interest in the different graphics we present. Preliminary results show that our stakeholders are happy with the writing style, content and length of the IWCS. Specifically, they are interested in regional climate information more than information limited to the scale of one state. We see that respondents use the IWCS primarily to better understand climate and hydrology, rather than as inputs to models.

The IWCS is an example of a climate service that is meeting the needs of our stakeholders by presenting clear climate information that is regionally focused and relevant to water resource decision makers in the Intermountain West. We will use the results of the survey to measure the success of our interactions with these decision makers, and we will adapt the IWCS in ways that will make it increasingly useful for them. This is an example of WWA using sustained interactions with stakeholders to increase and improve climate literacy.

Marsh, Patrick
School of Meteorology
University of Oklahoma

A Preliminary Investigation of Severe Thunderstorm Environment Distributions under Global Warming as Simulated by CCSM3

Co-author: Harold Brooks (National Severe Storms Laboratory) and David Karoly (University of Melbourne, Australia)

Global climate models (GCMs) are becoming increasingly important in the prediction of climate changes associated with an increase in anthropogenic forcing. However, little has been said about the effects of increased anthropogenic forcing on severe convective weather. Recent improvements in Community Climate Systems Model (CCSM) resolution and increased data storage capabilities have allowed for climate simulations of resolutions similar to those of the NCAR / NCEP global reanalysis to be archived at six hour intervals.

Brooks et al. (2003) demonstrated that threat of significant severe convective weather increases with increasing Convective Available Potential Energy (CAPE) and 0 to 6 kilometer deep layer shear. Additionally, Brooks et al. (2003) went on to demonstrate that the NCAR / NCEP global reanalysis data can be used as a surrogate for observational fields of several important convective parameters, including, but not limited to, CAPE, deep layer shear, and their combination. The methodology used by Brooks et al. (2003) will serve as the basis to examine changes in the severe weather environment under global warming as simulated by the CCSM3.

A brief comparison of the current CCSM3 severe thunderstorm environment to that of the global reanalysis data will be presented to illustrate the ability of the CCSM3 to simulate the severe thunderstorm environment qualitatively. This will be followed by a preliminary examination of the severe weather environment under the A2 SRES emission scenario. This examination of the simulated future climate will focus on the qualitative changes in the distributions of convective parameters – particularly CAPE, deep layer shear, and their combination.

Mason, Simon
International Research Institute for Climate and Society
The Earth Institute at Columbia University

Climate Information for Disaster Risk Management: Early Warning - Early Action

Co-authors: Walter Baethgen, Molly Hellmuth, Sylwia Trzaska, Michael Bell, Sarah Abdelrahim, Lisette Braman, and Arame Tall (International Research Institute for Climate and Society)

In 2008 the International Research Institute for Climate and Society (IRI) established a partnership with the International Federation of the Red Cross and Red Crescent Societies (IFRC). The partnership includes engagement at both the global and regional levels. On the global scale, IRI is helping to collect, process, and provide tailored monitoring and forecast information at a range of timescales. The information is being delivered through the IRI Data Library and Map Room facilities. The International Federation is utilizing the information to provide alerts and early warnings to regional and national offices, in order to prepare for possible disaster events in advance. The IFRC has, through this process, launched the program "Early Warning, Early Action", which represents a fundamentally new mode of operation – one that can utilize climate information to improve outcomes and increase effectiveness in the management of weather and climate related natural disasters.

The partnership also established programs in collaboration with regional/national offices in West Africa and Central America, two regions that are drastically affected by severe, deadly floods. Work was initiated with the Disaster Management Unit of the Red Cross office for West and Central Africa (IFRC-WCAZ), based in Dakar, to find ways to incorporate forecasts and other climate information into Red Cross decision-making. The IRI worked with the IFRC-WACZ leadership to develop a list of climate products that improve disaster preparedness. These include the PRESAO forecasts, the IRI 6-day rainfall forecasts, daily ACMAD bulletins and others.

The IRI also established work with the Water Center for the Humid Tropics of Latin America and the Caribbean (CATHALAC) and with regional and national offices of the Red Cross in Central America. More than a third of emergency appeals to the Red Cross's Pan-American Disaster Response Unit (PADRU) come from Central America and Mexico, and half of them are floods. Floods occur with significantly less forewarning than hurricanes, which are the region's other major weather threat and are well-tracked. Advanced warning of heavy rainfall and flooding can provide the opportunity to evacuate communities, preposition supplies, mobilize volunteers and save lives. The goals of IRI's work in Central America were to review the climate and weather monitoring and forecasting tools made available by CATHALAC and other agencies, and to understand the structure and decision-making process of the Red Cross so that these tools could be tailored to the organization's specific needs.

Mauget, Steven A.
USDA-ARS

The Value of ENSO Forecast Information to Dual Purpose Winter Wheat Production in the U.S. Southern High Plains

Co-authors: John Zhang (USDA-ARS El Reno, Oklahoma) and Jonghan Ko (USDA-ARS Fort Collins, Colorado)

The value of El Niño–Southern Oscillation (ENSO) forecast information to combined winter wheat and cattle grazing production systems over the U.S. Southern High Plains was estimated here by simulation. Although previous work has emphasized forecast information's average profit value, our approach was to estimate probabilities of the value of single forecasts from value distributions associated with categorical ENSO forecast conditions. Forecast value was calculated as the difference between profits from the stochastically dominant combination of applied nitrogen, planting date, and stocking rate for specific forecast conditions, and profits from dominant baseline practices that assumed no forecast information, i.e. climatology. A simple ENSO phase system's value was compared with that of an ideal forecast method that exactly predicted the tercile category of regional November-March precipitation. Simulations were conducted for four price scenarios with wheat prices that randomly varied about a historical ($3.22 bu-1) and elevated ($7.00 bu-1) mean, and with returns on live weight gain consistent with the grain producer leasing pasturage ($0.75 kg-1) or owning cattle ($2.42 kg-1). In the $3.22 bu-1simulations the best practices for specific forecast conditions varied with cattle ownership conditions. However, the ENSO phase system's value distributions were comparable to that of the perfect forecast system, which suggests that more accurate regional precipitation forecasts may not lead to more forecast value at the farm level. In the $7.00 bu-1 simulations, even perfect categorical forecasts produced minor profit effects. The best management practices for most forecast conditions planted on a date best for grain production, applied the maximum nitrogen level, and avoided stocking rates that might decrease grain yields. Because these practices were identical to the best no-forecast baseline practices, forecast value as defined here was $0.0 ha-1 under all but dry forecast conditions. The profit effect of dry forecasts from both the perfect and ENSO methods were negligible. This lack of forecast value is attributed here to increased profit margins rather than increased wheat value. But under both elevated and historical wheat price conditions the best no-forecast baseline practices are also shown to have value relative to an arbitrarily chosen management practice. Thus following practices optimized to climatology and current price and cost conditions might increase profits when no forecast information is available. Methods similar to that used here might be used as the basis of agricultural risk management tools, but these tools would require simulation models that are closely calibrated to the behavior of their real counterparts.

Noel, Jim
NOAA/NWS/Ohio River Forecast Center

National Water Resources Outlook

Co-author: Kevin Werner (NOAA/NWS/Colorado Basin River Forecast Center)

The National Weather Service (NWS) is moving toward a national Water Resources Outlook (WRO) based on the Ensemble Streamflow Prediction (ESP) system. ESP has been around since the 1970s and has been used in the Western Region of the NWS for many years to assist in water supply forecasts. With the implementation of the Advanced Hydrologic Prediction Service (AHPS), River Forecast Centers (RFC's) have been issuing 30- to 90-day probabilistic hydrologic forecasts for river forecast points using the NWS River Forecast System (NWSRFS) ESP system for almost a decade now. However, there has been no national product of being able to see how streamflows are expected to change in the coming months similar to what the United States Geological Survey (USGS) has for real-time data.

In 2005, the Ohio River Forecast Center (OHRFC) developed a WRO based on USGS observed streamflow categories which is operational now. It uses current soil moisture states from the hydrologic model and short term quantitative precipitation forecasts (QPF) from the National Center for Environmental Prediction's (NCEP) Hydrometeorological Prediction Center (HPC), the Climate Prediction Center's (CPC) 6- to 10-day, 30-day and 90-day temperature and precipitation outlooks, and the day 1 to 7 temperature departures from normal, which are derived from the National Digital Forecast Database (NDFD).

In 2008, the NWS WR began developing a WRO based on percent of normal for the coming months. In late 2008, the OHRFC and WR methods were merged into a national format that is being expanded across most if not all RFCs. It is using Google GIS graphics combined with NWS forecast data for one to three months into the future. This merging of methods into a national product is being done based on a growing demand and positive feedback from many customers at the federal, state, local and private sector levels.

The goal of this national WRO is to provide a continuous water watch from past and present into the future months to assist a wide range of customers in decision making processes. It allows the customers to visually see and drill down into climate hydrologic forecasts. Significant upgrades and expansion of this product is expected as we work with our customers in 2009 and beyond. This project has support at all levels within the NWS as well as from our customers.

Owen, Gigi
Climate Assessment for the Southwest (CLIMAS)
University of Arizona

Improving Stakeholder Access to Climate Information: Results from the Southwest Climate Outlook Evaluation

The Climate Assessment for the Southwest (CLIMAS) program was established to assess impacts of climate variability and long-term climate change on regional human and natural systems. The program's mission is to improve the region's ability to respond to climatic events and climate changes by working with scientists, decision-makers, resource users, educators, and others who need reliable, up-to-date information about climate and its impacts. As part of a larger stakeholder evaluation process at CLIMAS, we are assessing one of our main products, the Southwest Climate Outlook. This monthly online publication provides regional climate information to our stakeholders, including water and land managers, farmers and ranchers, researchers, non-profit organizations, and government agencies. After six years of publication, we want to know: a) who reads the Outlook, b) how readers use the Outlook, c) which sections are most and least useful, d) how the layout, graphics, and distribution methods help readers understand climate information, and most importantly e) how CLIMAS can make the Outlook better suit our readers' needs.

In this presentation I will discuss the data collection and analysis methods used to assess the Outlook, while focusing on the evaluation results in the context of improving the publication based on stakeholder feedback. The knowledge gained from this evaluation will not only help produce a better product, but also informs the CLIMAS program's long-term climate research and outreach efforts with its stakeholders.

Ray, Andrea
NOAA Earth System Research Laboratory

Climate Change in Colorado: Developing a Science Synthesis to Support Water Resources Management Adaptation

Co-authors: Joseph Barsugli (CIRES/University of Colorado), Kristen Averyt (Western Water Assessment/NOAA/University of Colorado), Veva DeHeza (Colorado Water Conservation Board), and Brad Udall (Western Water Assessment/NOAA Earth Science Research Laboratory)

The State of Colorado's Climate Action Plan sets out a goal to prepare the state to adapt to those climate changes "that cannot be avoided," and recommends assessing the vulnerability of Colorado's water resources to climate change, analyzing impacts on interstate water compacts, and planning for extreme events such as drought and flooding (CCAP 2007). The NOAA – University of Colorado Western Water Assessment, a Regional Integrated Science and Assessment (RISA) program, recently completed a report synthesizing the science on climate change. "Climate Change in Colorado: A Synthesis to Support Water Resources Management and Adaptation," is aimed at planners, decision-makers, and policymakers to support the state's water adaptation efforts.

This presentation focuses on the process of developing the report, our key communication goals, and the choices and challenges we faced in developing this synthesis for decision-makers, and engaging professional stakeholders in framing and developing the report based on their decision processes and needs.

A significant challenge was how to "downscale" knowledge for Colorado. We also took advantage of the IPCC Fourth Assessment and the very new Climate Change Science Program Assessments. However, although many published studies and datasets include information about Colorado, few climate studies that focus only on the state. Colorado-specific information is often imbedded in or averaged with studies of the larger Western U.S. To develop information at an appropriate scale, we used findings from peer-reviewed regional studies, and conducted new analyses derived from existing datasets and model projections, and took advantage of new regional analyses. The report is intended to raise climate literacy of our audience about climate and how climate science is done. For example, a primer on climate models and theory situates Colorado in the context of global climate change and describes how features such as complex topography relate to interpreting and using climate change projections.

Water managers have a history of adapting to changes in economies and land use, environmental concerns, and population growth. However, current practices may not be robust enough to cope with climate change. This report is a step in establishing Colorado's water-related adaptation needs; it responds to the needs of Colorado state agencies and water management community to evaluate impacts on Colorado's water resources and better understand risks. This report is also an experiment in climate services for climate change information and exploring the challenges of communicating the information to a diverse audience of decision-makers.

Redmond, Kelly
Western Regional Climate Center
Desert Research Institute

A Freezing Level Tool for Drought Monitoring

Co-author: John Abatzoglou (San Jose State University)

The freezing level is an important metric to water managers and hydrologists in mountainous terrain. This level has significant effects on accumulation, retention, and melting of snowpack, the main source of annual water supplies in many parts of the United States. The daily history of freezing levels has been assembled for a grid encompassing North America (in order to include Alaska) for a period extending from 1948, updated each day. A set of interactive tools accessible via the web to depict the characteristics of freezing level is under development. These include the ability to show time series of anomalies at a selected point for a given window of dates, or to show maps of long-term averages, departures from these averages, and trends through time, for windows of dates over user-specified time frames. Products include line graphs, maps, and data downloads. Other feature under consideration include temperature surfaces other than 0 degrees C, and counts of exceedances above or below specified thresholds.

Roncoli, Carla
Southeast Climate Consortium
University of Georgia

Moving Beyond the "Loading Dock": A Multi-Dimensional Evaluation of AgroClimate

Co-authors: Carla Roncoli (University of Georgia), Todd Crane (Wageningen University), Norman Breuer (University of Miami), Joel Paz (University of Georgia), and Gerrit Hoogenboom (University of Georgia)

Over the past two decades a paradigm shift has occurred relative to the nature and role of scientific knowledge in adaptive management. The traditional "loading dock" model, wherein technologies are developed by specialists working in laboratories and subsequently delivered to users by outreach mechanisms, is being replaced by a "co-production of knowledge" approach. This approach emphasizes context-specific "adaptation" rather than "adoption" of off-the-shelf technology and incorporates multiple kinds of knowledge held by both expert and non-expert stakeholders. Stakeholder-scientist interaction is at the core of the research agenda and outreach efforts of the Southeast Climate Consortium (SECC), one of the Regional Integrated Sciences and Assessment (RISA) projects of the NOAA Climate Program Office. In this paper we report on research to assess the salience, credibility, and accessibility of SECC information and tools from stakeholders' point of view. This assessment draws from stakeholders' feedback on the Agroclimate.org website, the main SECC outreach mechanism, including a suite of interactive climate-based tools. This feedback was elicited through a composite set of evaluation activities, including hands-on workshops and survey of agricultural extension agents and agriculture students, a survey of Instructional Technology experts, and laboratory-based usability testing. Additional information is drawn from interviews conducted with farmers in about twenty counties of South Georgia on their perspectives on what kinds of climate information would be useful to them and how it should be communicated. Results point to the need to ensure that information is easily accessed and understood, without overtaxing users' time, skills, and mental energy, and that it is conveyed in terms that are meaningful to them ("show you understand what it means to be a farmer"). In relation to the probabilistic nature of forecasts, it is important to convey information in ways that induce the right balance of caution and confidence and facilitate experiential learning. For example, providing elements for users to form their own assessment of the forecasts' past performance ("show the track record") and ways to compare them with local observations and experience would enhance their ability to interpret them and utilize them appropriately. Narrative accounts of personal experiences, editorials by well known extension professionals and other advisors, and biographic profiles and contact information of scientists ("show the people behind the website") would also foster greater ownership and habitual application among lay users. These findings elucidate the important role that users' responses and relationships play in the representation and interpretation of scientific climate knowledge and have led to substantial improvements of the SECC research and communication strategies, including agroclimate.org.

Rosendahl, Derek
School of Meteorology
University of Oklahoma

Estimating Uncertainties in Global and Regional Climate Change Projections Using a Large Multi-member Climate Model Ensemble

Co-author: David Karoly (School of Earth Sciences, University of Melbourne)

Information on the uncertainties in projections of future climate change is vital for their effective use across a wide range of applications. A multi-thousand member perturbed-physics ensemble of climate model simulations is used to better estimate model uncertainties in climate change projections for the globe and the North American region. Ensemble members have been generated by the distributed computing project climateprediction.net (CPDN) at the University of Oxford, where thousands of simulations have been run on PCs across the globe, each running a different version of the HadCM3 global coupled ocean-atmosphere climate model with perturbed parameterizations. This large ensemble provides a better assessment of model uncertainties on future projections than currently available from the 23 different models evaluated as part of the IPCC Fourth Assessment Report in 2007.

Transient climate change simulations are available from 1920 to 2080. This version of the HadCM3 model has horizontal resolution of 3.75 degrees longitude by 2.5 degrees latitude in both the atmosphere and ocean, and uses flux adjustment to maintain a stable control climate. For the period 1920 to 2000, the model is forced by observed changes in both anthropogenic and natural climate forcing factors, including changes in greenhouse gases and aerosols, and changes in solar irradiance and volcanic aerosols. For the period 2000 to 2080, the model is forced by projected changes in anthropogenic greenhouse gases and aerosols according to the IPCC SRES A1B emission scenario, a mid-range emission scenario.

A comparison is performed between each simulation of 20th century climate variations and the observed climate variations. Projections of climate change over the 21st century are obtained by weighting the different ensemble members by their goodness-of-fit to the 20th century observed changes, discarding those members considered to have inadequate simulations. This constrained data set is still composed of several thousand members and can be used to estimate probability distributions of mean temperature and precipitation change for a single future climate forcing scenario, which can provide insight into sources of model uncertainties in projected future climate change.

Preliminary results for probability distributions of changes in global mean temperature and regional mean temperature for North America will be presented, as well as an overview of the CPDN multi-member ensemble and the next steps of the project.

Schneider, Jeanne
USDA ARS Grazinglands Research Laboratory

Status Report: Assessing Decadal Precipitation Variations as Surrogate Forecasts

This is a continuation of work that was outlined at the 2008 CPASW, an attempt to produce monthly, location-specific probabilistic guidance with better skill than 30-year climatologies for U.S. locations with relatively weak ENSO signals. One of the goals is to develop a straight forward and easily applicable method for generating such guidance, to facilitate transfer to application communities. Progress to date and rationale for choices between options for approach will be discussed.

Serele, Charles
Agriculture and Agri-Food Canada

Predicting Spring Wheat Yields from Climate and Microwave Remote Sensing Data on the Canadian Prairies

Co-authors: Alan Basist (Commodity Hedgers Inc.), Aston Chipanshi (National Agroclimate Information Service), and David Waldner (Agriculture and Agri-Food Canada)

Researchers across Canadian Prairies have been developing models that forecast wheat yield in response to water availability. So far, in the Canadian Prairies, these models have achieved a reasonable level of precision. We are developing and testing new spatial modeling approaches involving the use of climate and microwave remote sensing data to improve the prediction of wheat yields. The objective of this project is to examine how well the combined use of climate and the Special Sensor Microwave Imager (SSMI) may be used to predict regional wheat yield across the Canadian Prairies. Weather stations-based precipitation, minimum and maximum temperature and multi-temporal remote sensing data obtained by SSMI, a passive microwave sensor aboard the DMSP (Defense Meteorological Satellite Program) series of satellites were used as inputs into a non-linear regression model. The combined use of climate and remote sensing data resulted in an improved prediction of regional wheat yields than when these inputs were used separately. Future work will explore the use of seasonal climate data as inputs so that the yield model can be used as a risk assessment tool.

Shafer, Mark
Oklahoma Climatological Survey
Southern Climate Impacts Planning Program (SCIPP)

Weathering Drought: One State's Experience

Co-authors: Bob Sandbo (Oklahoma Water Resources Board), Bryan Vance (Oklahoma Water Resources Board), Gary McManus (Oklahoma Climatological Survey), and Derek Arndt (Oklahoma Climatological Survey)

Oklahoma experienced one of its most severe, prolonged droughts during 2005-2006. Yet despite its severity, new tools and partnerships among agencies, developed over the previous decade, helped the state manage the drought with few crises. Water supplies shrank, in many cases to new all-time lows, but in all but a few cases both rural and urban water supply systems were able to meet demands. In addition, state and federal agencies were more coordinated and better prepared to assist both local governments and individuals who were suffering impacts from the drought.

The key to Oklahoma's recent success with drought response resulted as much from communication among agencies as it did through improved monitoring tools. The Oklahoma Mesonet, the backbone of regular drought assessments, provided localized information that allowed the Oklahoma Water Resources Board (OWRB), the state agency charged with the coordination of state drought monitoring activities, to remain one step ahead of most impacts. The Oklahoma Climatological Survey, which operates the Mesonet, coordinated the state's drought assessment with authors of the Drought Monitor to assure that a consistent picture was communicated to local and national decision-makers and the media. Within the state, information from the Mesonet, Drought Monitor, Corps of Engineers (reservoir levels), USGS (streamflow), and National Agricultural Statistics Service (crop conditions) were combined into a single document that was delivered at least bi-weekly to key decision-makers.

A major factor behind this success story was the OWRB's low-interest loan and grant programs for communities to upgrade water supply systems. Since 1984, more than $1.6 billion has been spent through the agency's Financial Assistance Program to increase system and community drought resistance. In addition, during this recent drought episode, the OWRB was able to provide emergency financial assistance to address more immediate water supply problems.

Although Oklahoma was relatively well prepared to address impacts of the 2005-2006 drought, there are areas for improvement. For example, the state requires more timely and accurate impact assessment and mitigation. Also, there is a need to synthesize climate and drought data in a more timely fashion for decision-makers. The ongoing development of the National Integrated Drought Information System (NIDIS), as well as proposed creation of a state drought portal, present excellent opportunities to improve Oklahoma drought management.

The state's recent drought experience demonstrates that quality, real-time information provided to key decision-makers, coupled with long-term planning by state and municipal water districts, is critical to drought preparedness. While Oklahoma experienced weather conditions that were at times as severe as the 1930s Dust Bowl, instead the state experienced only a short-term problem that left little social and economic disruption in its wake.

Shin, Dong-Wook
Center for Ocean-Atmospheric Prediction Studies
Florida State University

Sensitivity of Crop Yields to Various Weather Data

Author: G. Baigorria (University of Florida), S. Cocke (Florida State University), Y. Lim (Florida State University), T. LaRow (Florida State University), and J. O'Brien (Florida State University)

Can a dynamical regional model or a statistically downscaled data provide more accurate weather information compared to the ENSO-based weather for use in crop yield forecasting? Presently, the Southeast Climate Consortium (SECC) uses the ENSO-based daily weather data to project several crop yields (http://agroclimate.org/). Is this an optimal approach? Mostly likely not. To compare with this ENSO-based forecast, we are examining both dynamically downscaled daily data using the COAPS regional model (~20km) and statistically downscaled data from both the NCEP Climate Forecast System (CFS) and the COAPS global model. Yield sensitivity studies, employing the DSSAT crop model, are conducted by using these various daily weather data. In addition, sensitivity of yields to varying the planting start dates is also examined. Detailed results will be presented in the workshop.

Silva, Viviane
NOAA Climate Prediction Center

An Update of the NOAA/Climate Prediction Center GIS Project

Co-authors: Lloyd Thomas (NOAA/CPC), Kenneth Pelman (NOAA/CPC), Mike Halpert (NOAA/CPC), and Wayne Higgins (NOAA/CPC)

The NOAA/Climate Prediction Center (CPC) is working closely with the National Integrated Drought Information System (NIDIS) team to ensure the successful implementation of the integrated national drought monitoring and forecasting system. CPC is converting many of its products to GIS format (raster and shapefile) that will be used in the creation of the drought "early warning system." This system will be capable of providing accurate, timely and integrated information on drought conditions at the relevant spatial scale to facilitate proactive decision making aimed at minimizing losses associated with drought.

In this presentation we will give an update on the conversion of CPC monitoring and forecast products to GIS format, including the enhancement to the Grid Analysis and Display System (GrADS) by adding GIS vector and raster formats as output options.

Solis, Daniel
University of Miami

Climate-based Decision Making for Cattle Ranchers

Co-authors: Norman Breuer (University of Miami), Víctor Cabrera (University of Wisconsin – Madison), and David Letson (University of Miami)

Pasture and cattle production are highly influenced by climatic variability. If climate were known ahead of time, decisions could be made that would reduce the negative impacts of expected bad weather or take advantage of expected good weather conditions (Letson et al., 2005). Recent advances by scientists in understanding global ocean and atmospheric processes have led to new capabilities for forecasting climate several months to a year in advance (Jones et al., 2000). Most of these advances rely in some way on knowledge of the surface temperatures in the Tropical Pacific Ocean and the El Niño Southern Oscillation (ENSO) phenomenon (McPhadden et al., 2006).

In general most of the studies evaluating the impact of ENSO on agriculture have focus on a hand full of crops. Furthermore, ENSO effects on cattle ranching production in tropical and subtropical areas have been poorly studied. This study pretends to close this gap by offering a comprehensive analysis of the usefulness of climate forecasts on cattle production in Florida.

In doing so, we develop a set of maximization models to study the impact of climate variability on the different stages of production including 1) Pasture production; Ranch management; and 2) Resource management.

Our linkage of a grass production model, to a stocking rate, and a linear programming optimization or the cattle ranch as production unit may be useful for other researchers investigating economically feasible and sustainable management options based on improved climate forecasts. The model showed that the value of following recommendations based on ENSO forecasts ranged from US$11,990.55 to US$28,315.31. The value of the herd when recommendations to plant rye were not followed ranged from US$ -11,367.14 to US$11,409.00.

Solis, Daniel
University of Miami

Using Climate Forecasts to Reduce Risk in Dairy Farming

Co-author: Victor Cabrera (University of Wisconsin – Madison)

Since July 2008, dairy farmers in 35 states are able to lock-in their margins through the new livestock gross margin for dairy insurance (LGM-Dairy). LGM-Dairy is a risk management tool that allows farmers to hedge against loss of gross margin (market value of milk minus feed costs). LGM-Dairy gives farmers a way to control volatility in feed costs and milk prices. Farmers will estimate the volume of milk to be sold and the amount of feed (equivalents to corn and soybean) to be bought each month. Then, the expected gross margin (EGM) will be calculated using the Chicago Mercantile Exchange Class III milk futures and the Chicago Board of Trade corn and soybean futures. Prices for milk and corn (not soybeans) will be adjusted monthly by state. If the EGM is greater than the actual gross margin, the farmer will be paid an indemnity according to a selected deductible. Seasonal climate variability (e.g., El Niño Southern Oscillation) may impact feed costs and milk prices as well as milk production and feed consumption. Consequently, advancements in climate forecasting could play an important role in assisting farmers to decide on the most appropriate risk management strategy. The goal of this study is to offer an analytical tool to help farmers select the optimum level of LGM-Dairy when accounting for seasonal climatic variability. This paper (1) characterizes the historical climate impacts on dairy profit margins; (2) systematizes the indemnity calculation of LGM-Dairy; (3) introduces climate uncertainties to the optimal selection of a LGM-Dairy contract; and (4) explores the potential economic outcomes of locking-in margins under uncertain climatic conditions. Preliminary results indicate that seasonal climate variability impacts feed costs, milk production, feed consumption and milk price. Dairy producers could use climate forecasting to decide if it is convenient to purchase LGM-Dairy and at what EGM level. Under El Niño climate forecast, with expected above average feed costs, LGM-Dairy purchase with low or no deductible would be advisable, whereas during La Niña climate forecast a low premium or no LGM-Dairy would be a better option.

Tadesse, Tsegaye
National Drought Mitigation Center
Univ. of Nebraska-Lincoln

Discovering the Spatial and Temporal Relationships Between Vegetation Condition and Climate in Monitor Drought: A Case Study Over Central U.S.

Co-author: Jae H. Ryu (National Drought Mitigation Center, University of Nebraska)

Understanding temporal and spatial relationships of climate-vegetation interactions provide useful information on several aspects of vegetation and plant physiological activity. This helps to enhance our capability to monitor short-, medium-, and long-range prediction in monitoring vegetation conditions. In addition, determining the climate and vegetation response relationship varies both geographically and across the growing season which is a key component in improving drought monitoring and prediction. In this study, preliminary results in identifying the time-lag relationships between vegetation conditions and the preceding climate and oceanic conditions will be presented. The relationship between vegetation conditions, as observed from satellite over 18-year period (1989-2006), and several climate and oceanic indices that are associated with spatial and temporal variations were investigated using several statistical analysis techniques including Analysis of Variance (ANOVA). In this paper, we present initial results of the statistical analysis and techniques that have been used to identify the time-lag relationships between the climate/ocean condition and vegetation response over the central U.S. The correlation of the climate and vegetation response for each ecosystem in the 15 state-region, and the importance of these relationships to produce the vegetation outlook (VegOut) maps to monitor drought will be discussed.

Timmer, Reed
Cooperative Institute for Mesoscale Meteorological Studies, School of Meteorology
University of Oklahoma

Relations Between Temperature and Residential Natural Gas Consumption in the Central and Eastern United States

Co-author: Peter J. Lamb (Cooperative Institute for Mesoscale Meteorological Studies, University of Oklahoma)

The increased U.S. natural gas price volatility since the mid-to-late-1980s deregulation generally is attributed to the deregulated market being more sensitive to temperature-related residential demand. This study therefore quantifies relations between winter (November–February; December–February) temperature and residential gas consumption for the United States east of the Rocky Mountains for 1989–2000, by region and on monthly and seasonal time scales. State-level monthly gas consumption data are aggregated for nine multistate subregions of three Petroleum Administration for Defense Districts of the U.S. Department of Energy. Two temperature indices [days below percentile (DBP) and heating degree-days (HDD)] are developed using the Richman–Lamb fine-resolution (~1° latitude–longitude) set of daily maximum and minimum temperatures for 1949–2000. Temperature parameters/values that maximize DBP/HDD correlations with gas consumption are identified. Maximum DBP and HDD correlations with gas consumption consistently are largest in the Great Lakes–Ohio Valley region on both monthly (from +0.89 to +0.91) and seasonal (from +0.93 to +0.97) time scales, for which they are based on daily maximum temperature. Such correlations are markedly lower on both time scales (from +0.62 to +0.80) in New England, where gas is less important than heating oil, and on the monthly scale (from +0.55 to +0.75) across the South because of low January correlations. For the South, maximum correlations are for daily DBP and HDD indices based on mean or minimum temperature. The percentiles having the highest DBP index correlations with gas consumption are slightly higher for northern regions than across the South. This is because lower (higher) relative (absolute) temperature thresholds are reached in warmer regions before home heating occurs. However, these optimum percentiles for all regions are bordered broadly by surrounding percentiles for which the correlations are almost as high as the maximum. This consistency establishes the robustness of the temperature–gas consumption relations obtained. The reference temperatures giving the highest HDD correlations with gas consumption are lower for the colder northern regions than farther south where the temperature range is truncated. However, all HDD reference temperatures greater than +10°C (+15°C) yield similar such correlations for northern (southern) regions, further confirming the robustness of the findings. This robustness, coupled with the very high correlation magnitudes obtained, suggests that potentially strong gas consumption predictability would follow from accurate seasonal temperature forecasts.

Timofeyeva, Marina
NOAA Climate Services Division

NOAA NWS Local Climate Services Tools

Co-author: Jenna Meyers (NOAA Climate Services Division)

For the past 5 years the NOAA National Weather Service (NWS) has produced a number of local climate service products and tools available online for public access. These tools can be grouped in 4 main categories: Climate observations, Local forecasts, Training, and Outreach. Tools supporting Climate observations products include NOAA Online Weather Data (NOWData, powered by xmACIS), which allow users to obtain nine different climate summaries for nine climate elements at about 3900 locations. Local climate forecast tools allow overcoming barriers in forecast applications identified by Hartmann, et al. (2002), such as access for long term performance evaluation, dynamic forecast information support and interpretations. Training tools include about 30 hours of recorded online audio-visual training information related to Climate Variability and Change, Climate Prediction Center products, and Local Climate Products. Outreach tools include NWS climate focal point directory that is used for identifying climate user needs.

New user demands require expansion of NWS climate services tools. These include spatially distributed and presented information, different approach to presenting seamless suite of climate information and use of Geographic Information System (GIS) tools.

Trainor, Sarah
Alaska Center for Climate Assessment and Policy
University of Alaska Fairbanks

Improving Seasonal Fire Predictions and Information Services in Alaska for Regional and National Fire Resource Planning

Co-author: Paul Duffy (Neptune and Company, Inc.) and Daniel Ferguson (University of Arizona, CLIMAS)

Predictive capacity for Alaska fire falls behind what is available in the lower 48 states. Increases in wildfire frequency, severity, duration, and total area burned are among the most significant expected ecological effects of climate warming. Two of the three most extensive wildfire seasons in Alaska's 50-year record occurred in 2004 and 2005 and 60% of the largest fire years have occurred since 1990 (Kasischke et al. 2006).

In 2004, the largest fire season on record in Alaska, over 2.5 million hectares burned, costing state and federal fire agencies nearly $150 million. A Fairbanks neighborhood was evacuated multiple times and air quality in Fairbanks was classified as hazardous or unhealthy for nearly one quarter of the fire season. Population growth, road-building and resource development are increasing the need for fire suppression by expanding the area of wildland-urban interface. Furthermore, increased fire activity in Alaska increases nation-wide competition for limited and shared fire fighting resources.

Designed in close collaboration with fire managers from a range of state and federal agencies participating in the Alaska Wildland Fire Coordination Group, this project takes advantage of the strong weather/fire link in Alaska to produce estimates for the severity of the 2009 and 2010 fire seasons. The regression model developed by Duffy et al. (2005) estimates the logarithm of annual area burned as a function of monthly weather and teleconnection indices with an R-squared of greater than 75%. We extend this modeling framework through the application of gradient boosting models (GBM). Preliminary results show significant improvement over the already high R-squared from the regression model. The uncertainty associated with the forecasts will be quantified resulting in a set of possible values for area burned in Alaska and confidence intervals for the forecast.

In collaboration with CLIMAS, we are presently utilizing these results to draft a web-based decision-support tool that will help Alaska fire mangers adapt to a changing climate in their suppression and natural resource planning.

Verdin, Jim
U.S. Geological Survey
NIDIS Program Office

Update on Activities of the National Integrated Drought Information System (NIDIS)

Co-authors: Roger Pulwarty (NOAA) and Mark Shafer (Oklahoma Climatological Survey and Southern Climate Impacts Planning Program)

The National Integrated Drought Information System (NIDIS) was established to better prepare for and mitigate the effects of drought through development of a drought early warning information system. The NIDIS approach involves multiple, simultaneous efforts: a U.S. Drought Portal to condense information and make it more accessible to a wide range of users; integrated monitoring and forecasting; engaging preparedness communities; public awareness and education; and interdisciplinary research and applications. These five elements are integrated in a series of NIDIS Pilots. The first of these Pilots is the Upper Colorado River Basin, where large reservoir operators, water supply managers, and ecosystem recreational resource managers have become engaged with climate scientists to create a community that will collectively determine requirements, create online content, and analyze gaps in data and knowledge. Experiences from this first Pilot will inform development of subsequent Pilots, such as one in the Southeastern U.S. that will begin in 2009, as well as broader NIDIS products, services, and goals.

White, Dan
Alaska Center for Climate Assessment and Policy
University of Alaska Fairbanks

Alaska Center for Climate Assessment and Policy: Stakeholder Adaptation - from Citizens to the State

Co-authors: Sarah Trainor, John Walsh, and Craig Gerlach (Alaska Center for Climate Assessment and Policy)

The Alaska Center for Climate Assessment and Policy (ACCAP; www.uaf.edu/accap) is a NOAA funded, Regional Integrated Science and Policy (RISA) program (http://www.climate.noaa.gov/cpo_pa/risa/). ACCAP's mission is to improve Alaskans' ability to adapt to a changing climate. We partner with the University of Alaska's Scenario Network for Alaska Planning (SNAP; http://www.snap.uaf.edu/), state and local government, state and federal agencies, industry, and non-profit organizations to communicate accurate and up-to-date climate science and assist in formulating adaptation and mitigation plans.

ACCAP and SNAP scientists are members of the Governor's Climate Change Sub-Cabinet. Members participate in all aspects of the committee including its Adaptation and Mitigation Advisory Groups, the Research Needs Workgroup and Technical Working Groups (http://www.climatechange.alaska.gov/). ACCAP is also involved with regional county and municipal level climate change efforts, assisting them as they work through the five-step model for climate change planning put forward by the International Council for Local Environmental Initiatives (http://www.investfairbanks.com/Taskforces/climate.php).

ACCAP works closely with state and federal resource managers to advise state plans and policies on climate change. Due to climate change impacts on Alaska's coasts and rivers, communities are already being forced to relocate. ACCAP is presently preparing a document to advise state decision-makers on community relocation strategies. In this presentation we will discuss ACCAP stakeholder involvement strategies and applications that may be useful in other regions of the country.

Wiener, John
University of Colorado and NCAR

Suppose a Long View: A Framework for Sustainability Using Climate Information Applications

The climate information applications community has made remarkable progress, as all of these CPASW meetings have shown, in answering the questions of what users want, as well as the questions of how to use available climate forecasts and other information to improve the decision-making and general efficiency of a variety of sectors of the economy. The National Research Council review of SARP, and some of the Synthesis and Assessment Products (perhaps 5.3 especially) of the CCSP have confirmed this progress. Less appreciated outside the research group, perhaps, is that progress in learning how to develop applications with stakeholders, and how to work with them; others have addressed this very well. In the course of becoming user-centric, there is a new problem: we risk losing sight of the special values that scientific researchers in climate can bring. The foremost of these may be the fundamental acceptance of process and change over time – no one hearing this presentation will think that a snapshot of possible conditions in 2030 or 2050 or 2100 implies that the story ends there. We may not think that the question to be answered is, "How can I improve my short-term operations?", but our user-partners may think that. We may think the question is more like, "How can we improve short-term operations to enable sustainability and long-term management of critical resources?" Now, with a new administration and the IPCC AR4 and all that research on hand, the climate information applications community may have a "teachable moment" and this presentation will offer a framework for considering the long term in some ways that are understandable and explainable. This talk will be based on water, irrigation, and resource issues in Colorado, but the argument is broader. Even if the intended immediate beneficiaries of an application are looking only to get by (hard as that may be), we can offer the long view by looking at the five kinds of capital: natural, built, financial, individual, and social. The goal for adaptive management using climate applications is to shepherd those capitals through accelerating climate destabilization, not to aim for that snapshot, even if we needed to start with it to get people's attention. The work done by the climate prediction applications community has provided a basis for at least some applications efforts to bring in that long view.

Zierden, David
Center for Ocean-Atmospheric Prediction Studies
Florida State University

Multi-decadal Variability in Temperature and Precipitation in the Southeast United States

Co-author: Marcus Williams (Center for Ocean-Atmospheric Prediction Studies, Florida State University)

Much work has been done in characterizing inter-annual, or year to year variations in temperature and rainfall in the Southeast United states, especially as related to the El Niño-Southern Oscillation (ENSO). Studies have shown that Florida and the coastal regions of Alabama, Georgia, and the Carolinas can experience winter precipitation up to 50 percent above normal and cooler temperatures during El Niño episodes, while La Niña brings warmer winter temperatures (2 to 4 Celsius) and less rainfall in the cold season.

Further analysis of long-term weather records (80 to over 100 years) from National Weather Service cooperative observers also shows a coherent pattern of multi-decadal cycles in daily maximum and minimum temperatures across the region. This variability is characterized by relatively warm decades in the 1930's and 1950's and cold period from around 1960 through 1990. Superimposed on this region wide signal in the record are influences of land use changes such as the heavy urbanization and draining of wetlands in Southeast Florida and the conversion of the Everglades into agricultural lands south of Lake Okeechobee. Multi-decadal variations are also seen in temperature extremes, with clusters of severe freezes bringing fundamental changes to the citrus industry and other agriculture.

Multi-decadal variations in rainfall are not as clear as with temperature, with different parts of the region experiencing different changes. Alabama, Georgia, and North Florida have seen a recent increase in precipitation, with 1960-1995 being consistently wetter than normal. Central and South Florida show a decrease in summer rainfall during that same period, and a previous study has linked summer rainfall here to the Atlantic Multi-decadal Oscillation.

The nature of these variations will be explored, as will their applicability to long-term planning of water resources, agriculture, and natural resources.