

# The Climate Assessment for the Southwest:

## Program Summary for RISA Investigators Meeting

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### About CLIMAS

The intersection of climate variability and change with social phenomena such as population growth, cultural diversity, and climate vulnerability creates a complex environment for stakeholders in the semi-arid and arid southwestern United States. Resource and land managers concerned with maintaining the health of ecosystems and resources face serious climate-related challenges, including severe sustained drought, dramatic seasonal and interannual variations in precipitation, and steadily rising temperatures. Similarly, local, state, and tribal governments strive to maintain vital economic growth and quality of life within the context of drought, population growth, vector-borne disease, and fragile water supplies. These uncertainties at the climate-society nexus are prompting decision makers to seek out improved integrated knowledge in the natural and social sciences and tools to support decisions that can be informed by leading-edge science.

CLIMAS was established in 1998 to help address these concerns. With headquarters at the University of Arizona's Institute of the Environment, CLIMAS also has core researchers at New Mexico State University in Las Cruces, NM, as well as affiliated research partners at institutions throughout the region. The primary geographic focus of the program is Arizona and New Mexico, but members of the team work throughout the West and throughout Mexico. The CLIMAS program brings together a diverse group of researchers from disciplines across a spectrum of physical and social sciences, including: American Indian studies, anthropology, applied climatology, atmospheric science, economics, environmental studies, geography, hydrology, Latin American studies, paleoclimatology, and urban botany. CLIMAS researchers study the processes and effects of climate on the Southwest with individuals and organizations that need climate information to make informed decisions. In addition to carrying out a range of use-inspired science projects, the program has developed a variety of methods to promote the exchange of ideas and information among members of the public, private, nonprofit, and academic communities.

Throughout its history, CLIMAS has worked to assess climate variability and longer-term climate change in terms of impacts on human and natural systems in the Southwest. In doing so, it has also developed a substantial network of stakeholders, research collaborators, and partners. Through this large network, CLIMAS has carried out projects within a number of research themes, including: adaptation and vulnerability; climate science; the communication of science; decision support; drought; economics and livelihoods; ecosystems; health; and water. This work directly involves many sectors of the culture and economy of the Southwest, including: agriculture and ranching; ecosystem management; emergency management; energy; fire management; public health; tourism and recreation; urban planning; and water management.



# Core RISA Activities: 2010-2012

Consistent with projects conducted over the last decade under the CLIMAS banner, research over the next two years is integrative, interdisciplinary and cuts across sectors. The work broadly falls into six categories: research to support climate adaptation; support for drought planning; use-inspired climate science; development and provision of experimental climate services; evaluation of climate service models and modes; and development and refinement of decision-support systems.

## Research to support climate adaptation

Although many of the projects CLIMAS researchers are currently engaged in reflect the increasing need for more science to support climate adaptation, there are four specific projects that are directly focused on adaptation questions, including three economic studies: 1) an analysis of potential climate change and variability adaptation strategies in the water and energy sectors in the Southwest; 2) an analysis of different mechanisms for adapting to climate variability and change (including water markets, use of weather and climate information by agricultural producers, adoption of improved irrigation technologies, agricultural and other policy responses); 3) an analysis of impacts of drought and climate change on three climate sensitive sectors in the Southwest: agriculture, outdoor recreation, and tourism. CLIMAS researchers are also involved in an ongoing project examining adaptation and resilience to climate change, drought, and water demand in the urbanizing southwestern United States and northern Mexico.

## Support for drought planning

Like adaptation research, nearly all the work in the CLIMAS portfolio has some element of drought in it. Three specific new and ongoing efforts, though, are aimed directly at supporting drought planning in the region. First, members of our team are involved with ongoing state-level drought planning and assessment efforts in both Arizona and New Mexico. CLIMAS is also engaged with a multi-RISA effort to assess user needs for drought decision-making and the potential use of climate and drought information. Finally, CLIMAS has embarked on work to improve drought monitoring, planning, and mitigation on tribal lands in the Four Corner region of the Southwest.

## Use-inspired climate science

At the heart of the CLIMAS program since its inception have been a number of studies that have helped characterize the climate (past, present, and future) of the region and the impacts of climate change and variability on human and ecological systems. All of this work has been driven by both the fundamental quest for new knowledge as well as the needs of decision makers for better information about the climate of the region. Work in this domain over the next two years includes the development and implementation of the climate-based Dynamic Mosquito Simulation Model to understand and project climate effects on mosquito population dynamics, developing results that will help climate-health scientists and public health decision makers better understand and project the role of climate in actual disease cases. CLIMAS researchers are also engaged in a number paleoclimate studies to understand several aspects of the past climates of the region, including monsoon dynamics, hydrology and flood patterns of the past, and the patterns and causes of Southwest drought variability. Members of the CLIMAS team have also begun to explore what tree-ring records reveal about past climates of the tribal lands in the Four Corners region in an effort to provide tribal natural resource managers more information for contemporary drought planning.

## Development and provision of experimental climate services

Conducting experimental climate services has always been a central component of the CLIMAS program. Much of the work in this domain involves the continuation, expansion, and refinement of many of these services, although the next two years will also see the launch of new experimental climate service projects. A prominent element of our climate service portfolio is the monthly *Southwest Climate Outlook*. October 2010 will mark the 100th issue of the *SWCO*, which has evolved into a flagship product for the program. CLIMAS also helped to pioneer the National (now North American) Seasonal Assessment process for wildfire managers. This ongoing effort has continued to grow and evolve through time and has had a significant impact on the way that climate information is used by wildland fire managers. Aside from these two flagship services, members of the CLIMAS team are involved with many, many experimental climate service efforts, including trainings for National Weather Service personnel, conducting periodic climate briefings (for resource managers, members of the media, and the general public) giving frequent public talks on climate and climate change, working with various stakeholders on methods for improving decision making in the context of climate (e.g., scenario development), and responding to requests for information about drought and climate change. A new project coming online in fall 2010 will involve "Climate Bootcamps" to help improve the climate literacy amongst decision makers in the region. This project has been explicitly conceived as small-scale experimental pilot for what could perhaps be integrated into a National Climate Service.

## Evaluation of climate service models and modes

While members of our team have always included some measure of evaluation in their projects, in recent years CLIMAS researchers have begun efforts to take a more systematic approach to evaluating the various ways the program has conducted its research and provided climate services. Over the next two years, several members of the CLIMAS team will be working on focused evaluation projects that seek a more refined understanding of how the various modes and models deployed by the program are making an impact throughout the region. One prominent example is the effort CLIMAS researchers began last year (and still ongoing) to conduct a formal evaluation of the Arizona Drought Watch drought impact reporting system. Aside from evaluating the tool's utility from a user perspective, this project is explicitly examining the direct engagement methods used to develop the system to understand how effective those methods were in delivering a tool that meets user needs. CLIMAS is also involved with a project (currently in the data analysis phase) that is evaluating how climate and weather products (including those that we help develop) are impacting decisions made by wildland fire managers. This project is also using social network analysis methods to characterize the knowledge network amongst fire managers to better understand the flow of information within this community. Members of the CLIMAS team are also leading a project to examine in detail how climate information is making its way from research enterprises like the RISAs into water management decisions in three major cities in the West. Finally, evaluation is as an integrated element of a new climate literacy project being led by CLIMAS over the next two years. This project, which will involve "Climate Bootcamp" trainings for regional decision makers, provides an ideal opportunity for a fully integrated evaluation element that will provide insight into the successes and shortcomings of this particular experimental climate service.

## Development and refinement of decision-support systems

CLIMAS has developed and implemented numerous decision-support tools and systems over its history. Researchers on our team will be involved in the continued development, refinement and expansion of several tools over the next two years including: a new analysis "toolkit" for TreeFlow (drought planning resource for water managers using tree ring data); a decision tool to reduce drought vulnerability in the urban landscape sector; the Forecast Evaluation Tool (FET); Climate Information Delivery and Decision Support System (CLID-DSS); the Automated Hydrologic Threshold Alert System (AHTAS); and a Paleo-to-Projection Climate Change Scenario Synthesis Tool. Additionally, CLIMAS researchers are involved with several efforts to transfer tools developed by other RISAs to our region, including the Dynamic Drought Index Tool (DDIT) and AgroClimate.

CLIMAS will undertake the four projects listed below in support of the 2010 Assessment Services RFP issued by NOAA. These projects seek to build upon our well-established network of stakeholders and collaborators to: 1) broaden the scope of our existing work into new domains, emerging challenges, and underrepresented parts of our region; 2) make critical linkages amongst ongoing adaptation efforts across the region, and 3) expand the reach of CLIMAS's network. Collectively, these projects will contribute tangible inputs to the US National Climate Assessment effort (e.g., new analyses of climate vulnerabilities and implications of mitigation policies, catalogs of ongoing and planned regional adaptation and mitigation efforts, and locally-focused understanding of adaptation and mitigation needs and capacity). In addition to these product-based inputs, these projects will also help develop critical knowledge network infrastructure in support of the explicit desire for this National Climate Assessment effort to build a robust and enduring process.

# Assessment Services: 2010

## Knowledge Exchange and Needs Assessment on Adaptation to Climate Change in the Colorado River Basin

Most organized discussion about climate change within the Colorado River Basin (CRB) has addressed projected climate impacts and specific rules for operating under surplus and shortage. This project will move the discussion from awareness to action and coordination by assessing regional adaptation capabilities and cataloging existing adaptation efforts in the broader CRB. In collaboration with the Western Water Assessment (WWA) and California-Nevada Applications Program (CNAP), we plan to convene a workshop of key stakeholders and agencies from across a spectrum of sectors in the CRB to (a) foster communication of the extent of existing and planned climate adaptation initiatives, (b) catalogue projects, documents, and alliances whose work, expertise, and connections can be leveraged to develop sustained and ongoing assessment, (c) evaluate the scientific capacity within the region to address climate adaptation issues and to leverage existing federal labs, data centers, and new climate services initiatives (NOAA, DOI), and (d) assess science, decision-making, and communication needs in the region. The workshop will focus on water as the major medium through which climate change impacts will manifest in the CRB, and will look broadly at issues of both water and land management, as well as recreation, tourism, environmental flows, and urban adaptation.

## Assessing regional climate service needs through Cooperative Extension

Cooperative Extension (CE) has over 100-years of experience in delivering science-based decision support to clientele from multiple sectors. The CE structure enables a high level of connectedness and awareness of local issues and provides opportunities to assess local and multi-sector climate services needs. We will work through CE offices to capture snapshots of local climate science and services needs

across rural areas of AZ and NM. Since CE agents in these states work closely with both private land owners/producers (e.g. ranchers and farmers) and state/federal natural resource managers, we will be able to assess both the needs and interconnections between private and public resource managers, consistent with the 'nested matrix' concept of assessing climate change impacts and responses at multiple scales. This project will involve a series of focus groups with diverse stakeholders, from a range of different climate sensitive sectors, in each AZ county and in the three CE regions in NM. These may include community water providers, agricultural producers, land managers, private sector environmental consultants and watershed groups. Our partners, county (AZ) and regional (NM) extension directors, will help identify the relevant climate-sensitive sectors and key opinion leaders. The project is organized around two major themes: (1) assessing the adaptation and mitigation capacity of local stakeholders, and (2) identifying present and emerging local climate science and services needs. By adding questions targeted at key agricultural/natural resource extension agents and administrators, we will also conduct an AZ case study to assess the capacity of CE to respond to emerging needs for climate change adaptation and mitigation information.

### **Climate mitigation and agriculture: Public policy education**

Climate change mitigation policies (e.g. cap and trade) can raise farm revenues (e.g. agricultural carbon offsets) and energy-intensive input costs (e.g. energy and fertilizers). Mitigation is complex and controversial; thus, public policy education on costs and benefits can further inform agricultural producers and decision makers. To address these issues and provide useful information, we will analyze impacts of mitigation policies and assess how they might affect AZ and NM agricultural production and income, with a special focus on the high value fruit, vegetable, and nut crops important to Southwest agriculture. We will assess impacts on input costs, output prices and potential revenue from sale of agricultural carbon offsets, and quantify how allowances for energy intensive, trade exposed industries can significantly reduce agricultural costs. We will use representative farm analyses, which allow growers to estimate implications for their own operations. We will examine the scope for research and technology to simultaneously reduce mitigation costs and increase adaptive capacity, such as more efficient application of fertilizers or water (adaptation), which would also lessen impacts of increased groundwater pumping electricity costs (mitigation).

### **Poverty and climate change in the southwestern U.S.**

The U.S. Southwest is highly vulnerable to negative impacts of climate change, including increased temperatures, more severe droughts, and greater incidence of diseases. The poor in developing regions are more vulnerable to the impacts of climate change, such as extreme heat, flash floods, inadequate home heating and cooling, limited affordability of water, and problems associated with inadequate health care; they can also be disadvantaged by policies that seek to mitigate or adapt to climate change. AZ and NM have very high levels of poverty, with 20% of the general population living in poverty in 2008. Little is known about how the poor experience current climate variability in the Southwest, and even less about how the projected impacts of climate change and associated policies would exacerbate these factors. To address this dearth of information, we will: (1) use AZ and NM census and other data to provide a regional overview of poverty and related indicators of vulnerability to climate change and will examine the extent to which current climate policy and programs address the challenges of poorer populations; (2) examine detailed relationships between poverty and climate change through case studies of high-poverty communities in southern AZ including Tucson/South Tucson, Bisbee/Sierra Vista/Douglas, Yuma, and rural areas of southern AZ; (3) use census and socioeconomic data (e.g., energy and water costs) to define baseline characteristics of the relationships between poverty and climate in southern AZ; (4) conduct semi-structured interviews with a non-probabilistic target sample of 50-60 agencies and NGOs to identify key climate-related vulnerabilities that correspond to particular groups; (5) convene a stakeholder workshop to gather input on highest priorities, next steps, and strategies for reducing community climate change impacts.

## **Support for Long-Range Decisions**

As the brief descriptions of core and assessment services activities above indicate, members of the CLIMAS team are actively involved in research in support

of decision making at multiple scales in our region. Below are examples of the types of questions the CLIMAS team is working on that are directly tied to long-range policy decisions in the Southwest.

### **How will surface water and groundwater supplies in the region be impacted and therefore managed in the context of population growth and a warming climate?**

Because water is the key variable in many of the major long-range planning decisions being made in the Southwest, it is central to much of the work that CLIMAS researchers conduct. From scientific studies of paleoclimatic conditions of the region (including past monsoon dynamics) to direct engagement projects aimed at delivering the best available climate information to water managers to efforts to improve drought monitoring and planning efforts in both urban and rural parts of the region, members of the CLIMAS team are supporting a whole host of decisions at multiple spatial scales related to water.

## What data and information do governments in the region need to develop useful and usable climate mitigation and adaptation plans?

CLIMAS is helping to support both multiple government entities in our region with efforts to plan for a changing climate. For example, in the urban context, CLIMAS is helping the City of Tucson assemble the best available science related to projected regional climate changes and impacts as part of the city's current process to develop a climate change adaptation plan. Examples from rural Arizona include work by CLIMAS researchers to improve drought planning processes in the Four Corners region; this work is being conceived by both the researchers and the stakeholders as an initial step toward longer term climate adaptation planning.

## What are the major climate justice issues confronting decision makers in the Southwest as the climate continues to warm?

CLIMAS has historically worked with rural stakeholders on assessing vulnerabilities of climate sensitive livelihoods. New and evolving work, though, has begun to look explicitly at climate justice issues throughout the region including along the US-Mexico border, in poor urban populations, and with Native American communities. The vulnerability of these and other populations in the region raise important justice issues surrounding numerous long-range decisions about, for example, water resources, energy, and infrastructure investments. As the region continues to warm and likely become more arid, decision makers will be confronting difficult choices that will require a much better understanding of the region's most vulnerable groups.

## How will ecosystems be impacted and therefore managed in the context of a warming climate?

Agencies and individuals responsible for managing landscapes in the Southwest are confronting the uncomfortable reality that many of these landscapes are undergoing transformations driven by both climate and land use. These changes complicate decisions natural resource managers make on scales from seasons to decades. CLIMAS researchers are engaged with managers and NGOs throughout the region on efforts to bring the best available climate science to bear on extremely challenging ecosystem decisions like whether a species habitat will be too imperiled in coming decades to continue committing resources to its protection.

## How will the frequency and intensity of extreme events change in coming decades and how can decision makers best prepare for potential changes?

Extreme events are endemic to the climate of the Southwest. From rapidly developing hazards like flash floods and extreme wind events to slow-moving phenomenon like drought, decision makers in the region are used to confronting threats from climate and weather. Whether or not these inherently difficult to predict events will remain in the bounds of past experience is a question of deep importance for many stakeholders in the region. Much of the CLIMAS work on drought, climate dynamics of the region, and past flooding has direct implications for stakeholders charged with developing systems more resilient to extreme events.

# Local-to-Regional Decisions

Many of the climate-related decisions made at the local level in the Southwest have implications for the region. A negotiated

water settlement by local entities can have direct and long lasting implications for the region as a whole. For example, the Arizona Water Settlement Act in 2004 essentially settles the water claims of one tribal community, the Gila River Indian Community, but has implications for many other water stakeholders in the region. Another example that involves the precious surface water in the region comes from the agricultural sector. Decisions made by producers about, for example, fertilizer or pesticide use, has water quality implications for everyone downstream, especially in the context of an overallocated system like the Colorado. In the Four Corners region one can easily see examples of energy development and other land use decisions by local entities impacting the air quality of the entire region. In a similar way, decisions made by resource managers in the headwaters region of any major river system can and

often do have significant implications for stakeholders downstream. These examples are all drawn from experiences CLIMAS researchers have encountered as we have worked to bring the best available research to what are very often incredibly difficult and far-reaching decisions by stakeholders in the region.

For more information about CLIMAS, including details about past and ongoing projects, annual reports, profiles of our investigators, reports and publications by our team, links to web tools, and much more, visit our website at:

<http://www.climas.arizona.edu>

