Integrating Climate Science for Decision-Support, Mitigating Risk and Promoting Resilience Climate Assessment for the Southwest (CLIMAS) Phase 3

Annual Report
for
August 1, 2007–April 30, 2008

Contents

CLIMAS Project Team

Investigators

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Don Anderson, Ashley Coles, Roland Diaz Caravantes, Jeanette Estes, Stephanie McAfee, Cory Morin, Anand Murugesan, Rachel Novak, Cody Routson, Peter Taber, James Tamerius, Paulo Tanimoto

Main Stakeholders and Partners

Agri-Business Council of Arizona
Apache County Arizona
Arizona and New Mexico Cowbelles (volunteer organization)
Arizona Cooperative Extension
Arizona Department of Environmental Quality
Arizona Department of Health Services
Arizona Department of Water Resources
Arizona Riparian Council
Arizona State University's Decision Theater
Arizona Water and Pollution Control Association
Arizona Water Institute
Arizona-Mexico Commission
California Department of Water Resources
Catron County (New Mexico)
Catron County Citizen's Group
Chambers of Commerce for Holbrook, Show Low, Springerville, St. John's, and Glenwood (Arizona)
Cities of Holbrook, Show Low, Springerville, and Eagar (Arizona)
Concho Community Center (Arizona)
East Valley Water Forum (Arizona)
Elephant Butte Irrigation District (New Mexico)
Forecast Evaluation Tool (FET) users including public agencies, private organizations (e.g., energy and commodity firms), and individuals.
Friends of the Santa Cruz River (Arizona)
Local communities in U.S.-Mexico Delta region
Middle Rio Grande Conservancy District (New Mexico)
Multiagency Task Force of Arizona Flood Warning and Drought Monitoring System
National Interagency Coordination Center
National Park Service
National Wildlife Federation
Natural Resources Conservation Service
Navajo County Arizona
Navajo Nation
New Mexico Cooperative Extension
New Mexico Department of Agriculture
New Mexico Drought Monitoring Work Group and Drought Task Force
New Mexico Office of the State Engineer
Pima County Arizona
Pima County Regional Flood Control District
Salt River Project (SRP)
Sonoran Institute
Sustainability of semi-Arid Hydrology and Riparian Areas (SAHRA) NSF Center
The Nature Conservancy
Tubac Presidio State Park
Tucson Department of Transportation
Tucson National Weather Service Forecast Office
Tucson Water
Tumacacori National Historical Park
UCAR Cooperative Program for Operational Meteorology, Education and Training (COMET)
University of New Hampshire Earth System Observatory (UNH EOS)
US Forest Service (particularly the Apache-Sitgreaves National Forest in Arizona and the Gila National Forest in New Mexico)
US Geological Survey
Various Arizona county flood managers

Areas of Focus

During the performance period, CLIMAS team activities fell into four broad categories with numerous focus areas in each category:

1. Capacity building
   - 1.1. Enhance climate services and web resources in New Mexico.
   - 1.2. Improve forecast evaluation and apply in operational settings
   - 1.3. Develop and implement decision support tools
   - 1.4. Improve drought impact reporting
   - 1.5. Develop hydroclimatology and paleohydrology for decision support
   - 1.6. Build capacity for climate knowledge application in Native American Communities and in the US-Mexico border region
   - 1.7. Conduct fire-climate science and facilitate translation
   - 1.8. Translate climate variability and climate change science for stakeholder needs
   - 1.9. Provide decision support for climate change adaptation
   - 1.10. Improve CLIMAS internal and external interactions through evaluation
2. Understanding decision-maker needs
   - 2.1. Improve the use of climate information in agricultural decision-making
   - 2.2. Understanding perceptions of climate variability and change in the US-Mexico border region
   - 2.3. Understand the role of water transfers and federal farm policy in drought mitigation
3. Climate Research
   - 3.1. Increase understanding of finer scale climate variability in the US Southwest
   - 3.2. Improve understanding of climate dynamics of the Southwest in the global system
   - 3.3. Explore potential hydrologic and land-cover impacts of climate change
   - 3.4. Improve understanding of connections between climate and public health
4. Vulnerability
   - 4.1. Assess community vulnerability through case studies
   - 4.2. Map vulnerability of the Southwest
   - 4.3. Assess economic impacts of drought and climate change on agriculture
   - 4.4. Assess economic impacts of climate variability on Southwest park recreation

Research and Stakeholder Collaboration Highlights

1. Capacity building

1.1 Enhance climate services and web resources in New Mexico

- Implementing the Southeast Climate Consortium AgClimate decision-support tool and the Carolina Integrated Science Assessment Dynamic Drought Index (DDIT) in New Mexico (Bathke, Garfin, and Hartmann).
- Developing new database and data access system for New Mexico climate data. An initial version of this is available at http://nmcc.nmsu.edu/web/data/. In the coming months we will work with stakeholders and conduct focus group studies to gain feedback from users (Bathke).

1.2 Improve forecast evaluation and apply in operational settings

- Conducted professional development training on hydrologic forecast verification of National Weather Service (NWS) operational forecasters (Hartmann).
- Continued to work with UCAR Cooperative Program for Operational Meteorology, Education and Training (COMET) to develop their training materials, and to engage with Western Region Headquarters (WRHQ) and the Office of Hydrologic Development (OHD) related to hydrologic forecast verification (Hartmann).
- Continued to support training of NWS Climate Focal Points (CFPs) in collaboration with Climate Services Division of the Office of Weather, Water, and Climate Services (CSD/OWWCS). CSD/OWWCS provided unsolicited contract, "The Forecast Evaluation Tool: expansion and support of climate services," for $75,000 over a 5-year period (2007-2012). This contract represents a significant funding stream for that office, the commitment to on-going use of the Forecast Evaluation Tool (FET) by NWS Weather Forecast Offices (WFOs) and users of the L3MTO local seasonal outlooks developed at CSD, and the interest by CSD in continued development of FET functionalities (Hartmann).
- Received approval of a three year project as part of the NWS Climate Test Bed (CTB), "System-wide advancement of user-centric climate forecast products", $433,572 (2007-2010). While this project is largely related to decision support tool (DST) development, it has a significant forecast evaluation component; as part of this project, online user-centric evaluation capabilities will be an integral part of new forecast products (Hartmann).

1.3 Develop and implement decision support tools

- Created the Dynamic Mosquito Simulation Model (DyMSiM), which uses climate data for input (temperature, precipitation, daylight hours) to simulate mosquito populations. Considered to be among the first and most complex dynamic climate-mosquito simulation models available (Comrie).
  - » Calibrated model for two relevant mosquito species, *Aedes aegypti* and *Culex quinquefasciatus*.
  - » Derived model output for appropriate areas while taking land cover and land use into consideration.
- Transitioned Forecast Evaluation Tool (FET) from beta version to full release, with implementation of redesigned bubble chart. Approach developed for allowing new components that are still in beta release within FET; they are noted as such on the site (e.g., L3MTO outlooks), enabling maximum availability of new functionalities while flexibly using available funds for continued incremental site development (Hartmann).
- Progress on the Climate Information Delivery and Decision Support System (CLIDDSS) (Hartmann)
  - » Linking high-priority external information providers to CLIDDSS through CTB project and engagement with NOAA Pacific Region Integrated Data Enterprise (PRIDE) researchers. Progress will continue, especially in conjunction with Coping with Drought projects with CISA, WWA, and SECC.
  - » Training information intermediaries in use of CLIDDSS. Initial training of CLIMAS Core Office, as initial intermediary, was achieved, and resulted in the first application of CLIDDSS, in a pseudo-operational setting, with the generation of March 2007 issue of US/Mexico Border Climate Summary newsletter. Training continues and will be extended to others, including SECC and CISA, through Coping with Drought projects.
  - » Developed guidelines for information producers to develop web services capabilities through using CLIDDSS. Engaged with information providers and intermediaries engaged with PRIDE and Integrated Data and Environmental Applications (IDEA) programs at PRIDE Investigators Meeting & Pacific Region Data Integration and Visualization Workshop.

» Supported stakeholder workshop with UNH EOS to explore potential application of CLIDDSS in conjunction with their decision support tools.

- Focusing on approaches for efficient and effective development and sustainability of decision support tools. Efforts have focused on providing information back to NOAA and the broader climate research and applications community (Hartmann).
  - » US Climate Change Science Program (CCSP) Product Development Committee (CPDC) for Synthesis and Assessment Product 5.1, Uses and Limitations of Observations, Data, Forecasts, and Other Projections in Decision Support for Selected Sectors and Regions, author of chapter, "Water Resources Management."
  - » US Climate Change Science Program (CCSP) Product Development Committee (CPDC) for Synthesis and Assessment Product 5.3, Decision Support Experiments and Evaluations Using Seasonal to Interannual Forecasts and Observational Data, work group participant.
  - » Liaison with the Earth Science Information Partnership (ESIP) Federation and members. This led to development of the proposal to the NOAA RISA program, "A multi-scale mid-Atlantic regional integrated sciences and assessments project" with George Mason University (GMU), the ESIP Federation, and Northern Shenendoah Valley Regional Commission, among others ($3,017,000 for 2008-2013). This also has led to organizing a panel session on decision support tool development at Climate Prediction Applications Science (CPAS) workshop, and no-cost attendance at ESIP Federation meetings for RISA researchers.
  - » Serving on American Meteorological Society (AMS) Committee and Boards concerned with development of national climate services and the role of the public, private, and academic sectors within the climate service enterprise.

1.4 Improve drought impact reporting

- Involved with the Arizona Statewide Drought Program (ADWR). Garfin co-chaired Arizona Drought Monitoring Technical Committee. Advised process of developing county-based Local Drought Impact Groups in Santa Cruz, Graham, Navajo, Pinal, and Pima Counties as part of implementing the Arizona Drought Preparedness Plan (Garfin).

1.5 Develop hydroclimatology and paleohydrology for decision support

- Developing a flood hydroclimatology dataset with the intended goal of integrating with the Arizona Flood Warning and Drought Monitoring System (AFWS)–or a similar platform– to provide a climatic perspective on the causes and variability of past extreme flood events and their probability of occurrence under different types of atmospheric circulation patterns (Hirschboeck).
  - » The groundwork for a hydroclimatically classified dataset of instantaneous peak streamflow records has been compiled for 500+ USGS stream gauges in Arizona.
  - » Collaborating with stakeholders to envision ways to provide a climatic perspective to flood risk management practices.
  - » The dataset now exists in prototype form. (This part of the project has been leveraged with a Translational Science Fellowship award and has the ultimate goal of developing a proposal to further this work.) An informal partnership has been established with the AFWS Multi-Agency Task Force to pursue this project.
- Identifying cultural factors that affect risk perception and behavior during a flash flood. An intended use of the results is to guide stakeholders and university researchers with collaborations to create flood warning products designed with these cultural factors in mind (Hirschboeck and Coles).
  - » Approximately 1000 surveys were mailed to residents across Tucson in October 2007; 170 responses returned. Data are currently being analyzed.
- Developing a framework for the use of dendrochronologic data in water supply management and drought planning. This framework is being produced in collaboration with the Arizona State University (ASU) Decision Theater and the East Valley Water Forum (Hirschboeck).
  - » Initial hydroclimatic scenario products are now being developed and presented as part of a webpage titled: A Framework for Generating Scenarios of Drought Conditions Using Tree-Ring Information. http://fp.arizona.edu/kkh/awi/awi.htm
- Transfering the knowledge and record length that paleodata provide into useful tools for water resources decision support through: (1) development of relevant tree-ring based streamflow information for the Southwest, (2) analysis and interpretation of this information in the context of the observed record and current hydroclimate (drought) conditions, and (3) interactions with stakeholders to collaboratively develop interpretive guides on the use of tree-ring data in water resources management. This is an expansion into the Southwest of the approaches described at the NOAA Paleoclimatology TreeFlow project website, developed for Colorado by Connie Woodhouse and Jeff Lukas. http://www.ncdc.noaa.gov/paleo/streamflow/ (Hirschboeck).

» Updated reconstructions for the Salt, Verde, and Tonto river basins completed and preliminary results presented to the Water Resources Operations group of Salt River Project (SRP). Based on input from this group additional processing of the data and a final report is underway. An accompanying study is analyzing the hydroclimatology of extreme high and low annual streamflow years and linking them to defined anomalous atmospheric circulation patterns.

◊ Preliminary results indicate that six past droughts (since 1330 A.D.) were comparable in severity to the recent 1999-2004 drought period. The individual years 2002 and 1996 appear to be the most extreme years since 1330 A.D. in terms of reconstructed low streamflow.

◊ After SRP stakeholders (at Nov 27, 2007 SRP workshop) requested information on high flows and wet years (in addition to low flow information) the flood hydroclimatology data for the Verde River from the prototype dataset was integrated with our tree-ring reconstruction results for the Verde River to address the usefulness of tree-ring information as indicators of high flows and floods. These new results were presented in our February and April presentations to SRP.

» This study is completed and the final report is under preparation. A presentation and handout of the results is available at: http://fp.arizona.edu/kkh/srp2.htm and the completed final report will be available at this same URL later in May 2008.

1.6 Build capacity for climate knowledge application in Native American communities and in the US-Mexico border region

- Assessment of the Navajo Nation Hydroclimate Network (leveraged with Arizona Water Institute project AWI-07-21). This work was a direct offshoot of meeting Navajo Nation Department of Water Resources official Teresa Showa at the 2006 NOAA Drought Retreat. Information available at http://www.u.arizona.edu/~gmgarfin/nnawi.html (Garfin).
- Supported (with leverage of outside fellowship funds) the completion of Rachael Novak's Master's thesis "Climate Variability and Change in the Chuska Mountain Area: Impacts, Information, and the Intersection of Western Science and Traditional Knowledge." This work focuses on climate variability and change on the Navajo Nation (Overpeck).
- Wilder research group has fomented translation to Spanish of CLIMAS website, and will continue to be centrally involved in this in the future.
- Disseminating "Climate Change Beyond Borders, Drought Beyond Borders," K-8 Bilingual (Spanish and English) lesson plans for teachers in the Arizona-Sonora region. Available at http://udallcenter.arizona.edu/publications/santacruzwatershed/.

1.7 Conduct fire-climate science and facilitate translation

- Co-organized two National Seasonal Assessment Workshops to provide pre-season fire potential forecasts for the United States. For the Western U.S. meeting, Garfin organized participation by colleagues in Mexico, in order to promote timely exchange of cross-border fire information (Garfin).

1.8 Translate climate variability and climate change science for stakeholder needs

- Produced eight issues of the Southwest Climate Outlook (SWCO) and distributed to approximately 1600 people via e-mail (Bathke, Garfin and core office).
- As a follow-up to a December 2006 briefing to Tucson Water hydrology and engineering unit, provided requested updated information on climate changes affecting Tucson Water's management and water supply regions for Tucson Water long-term plan (Garfin).
- Contributed climate analyses for four chapters of the Arizona Department of Water Resources Arizona Water Atlas (Garfin).
- Contributed to Western Governors' Association, Western States Water Council, California Deportment of Water Resources May 2007 Climate Change Research Needs Workshop. See Proceedings, p.18-19, Appendices B, C, D. available at http://www.westgov.org/wswc/publicat.html (Garfin)
- Briefed the Arizona-Mexico Commission "Water Table" on climate change projectors and potential impacts in the Arizona-Mexico border region (Garfin).
- Contributing authors for U.S. Climate Change Science Program Synthesis and Assessment Product 5.3: Decision-Support Experiments and Evaluations Using Seasonal to Interannual Forecasts and Observational Data (Garfin and Morehouse).

1.9 Provide decision support for climate change adaptation

- Developing climate change projections and scenarios for the Southwest. A conceptual framework for scenario development and application was developed last year in collaboration with the SAHRA NSF Center. This collaboration has continued and provided a foundation for stakeholders to solicit CLIMAS involvement in their projects related to climate change adaptation and scenario planning (Hartmann).
  - » Professional development training and discussion about scenario planning framework for water management sector. SAHRA hosted a day-long training seminar in conjunction with the Arizona Hydrological Society Annual Meeting, attended by local and state agencies, non-governmental organizations, and consulting firms from Arizona, New Mexico, and Texas.
  - » Collaborated with the National Park Service in assessing scenario planning framework application to NPS-wide climate change adaptation planning efforts. The NPS Climate Change Initiative Coordinator, Leigh Welling, sought out CLIMAS involvement. The project involved working with the University of Montana, National Park Superintendents, regional cultural and natural resource managers, and park staff through an extended series of teleconferences, online work sessions, and a two day workshop, with case study application of a scenario planning process to two parks, Joshua Tree and Koloko-Honokuhau. The goal is to develop an approach that can be applied across the National Park system for each park unit to develop climate change adaptation plans. Greater involvement of the NPS and engagement with other land management agencies (Fish and Wildlife Service, Forest Service) is expected in 2008.
  - » Engaged the Carpe Diem project, headed by Ex Loco, Inc. This project involves a wide variety of large and small non-governmental organizations and foundations in developing a sector-wide strategy for developing funding projects to facilitate climate change adaptation within the water management sector in the US West. Activities this year have focused on developing relationships; continued involvement is expected throughout 2008.
- Began work with Arizona Department of Environmental Quality leadership to begin planning a climate change adaptation initiative for Arizona (Overpeck and core office)

1.10 Improve CLIMAS internal and external interactions through evaluation

- Conducting a pilot evaluation of CLIMAS team interactions with stakeholders and partners to understand penetration of information; perceived salience, credibility, and legitimacy of CLIMAS; and changes in knowledge, behavior, understanding as a result of interactions with CLIMAS. This project, supported by Coping with Drought funds, includes investigators from within the CLIMAS team as well as four investigators from outside the team (Ferguson and Garfin).
  - » Interviews, a survey, and focus groups will assess the various interactions CLIMAS team members have with approximately 150 stakeholders and partners. Data collection is underway.

2. Understanding decision-maker needs

2.1 Improve the use of climate information in agricultural decision-making

- Conducted an internet climate needs assessment survey directed toward New Mexico Extension Agents and Specialists (Bathke).
- Examined the sources of information used by farmers and ranchers to improve irrigation and the barriers to water conservation
  - » Prepared and submitted "Farm Size, Irrigation Practices, and Conservation Program Participation in the Southwest," Irrigation and Drainage, (in 2nd round review) (Frisvold).
- Conducted multivariate regression analysis of factors explaining use of weather data by 300+ Arizona and farmers and ranchers from USDA Policy Preference Survey data (Frisvold).

2.2 Understand perceptions of climate variability and change in the US-Mexico border region

- Assess perceptions of climate variability and climate change by institutional stakeholders and local communities across the Colorado River Delta region on both sides of the border (Wilder).
  - » Held a daylong workshop in Yuma, Arizona with NGO collaborators Sonoran Institute (SI) and National Wildlife Federation to plan joint research projects and design community household survey.
  - » Surveyed 830 households in three research areas: a. U.S. Limitrophe communities; b. Mexican Limitrophe communities; and c. Restoration zone communities (i.e., three communities in the Delta where SI is working to restore native habitat).

- Examine the linkages among water conservation, perceptions of drought and climate change, and valuation of riparian wetland areas by local communities.

2.3 Understand the role of water transfers and federal farm policy in drought mitigation

- Examining water transfers as a drought mitigation tool in the Southwest and how climate change may affect these transfers. Goal is to better understand the implications of water transfers in the context of climate change.

3. Climate research

3.1 Increase understanding of finer scale climate variability in the US Southwest

- Identified the leading causes of the observed patterns in fine-scale precipitation anomalies by focusing on the spatial and temporal distribution of winter precipitation anomalies within smaller sub-regions of the Southwest. Using the North American Regional Reanalysis data set, we analyzed differences between hypothesized controlling atmospheric variables under contrasting intra- and inter-seasonal variability for a set of key sub-regions. Initial findings are below (Comrie).
  - » Interactions between synoptic and local-scale processes produce several key permutations of locally-contrasting winter precipitation anomalies.
  - » Many of sub-regional precipitation patterns delineated in our work are related to regional-scale precipitation patterns and their interactions with finer-scale topography and related local circulation effects.
  - » Regional-scale precipitation patterns are closely linked to inter-annual variability of large-scale circulation (e.g. position of Pacific-high, position of Aleutian-low, activity of southern jet).
  - » Although adjacent sub-regions in the Southwest U.S. may be highly correlated with respect to winter precipitation, correlations between sub-regions can become unstable during certain winters, when:
    - ◊ Large-scale circulation regimes affect the synoptic-scale characteristics of precipitation events in a region over the course of a winter.
    - ◊ The synoptics of the event favor precipitation in one sub-region over an adjacent sub-region, and precipitation relationships between the sub-regions can become skewed and result in contrasting precipitation anomalies.
    - ◊ Local topographic features become partially responsible for creating finer-scale differences by amplifying and/or suppressing precipitation at distinct points under different large-scale and synoptic conditions.

3.2 Improve understanding of climate dynamics of the Southwest in the global system

- Continued to support PhD thesis work of Stephanie McAfee on the influence of the Northern Annular Mode on Southwest climate, and watershed management implications. This work led to completion of a paper for submission to a peer-review journal (Overpeck).
- Started work with new PhD student Cody Routson (leveraged by Science Foundation Arizona fellowship funds) on paleoclimate of the Four-corners region. Cody is jointly supervised with Dr. Connie Woodhouse, and hence represents a cross-RISA effort.
  - » In 2007, we collected tree-ring and remnant wood samples from the San Juan Mountain headwater region of Colorado. Also collaborated with others on related study of climate and mineral aerosol deposition in the Four Corners region (Overpeck).
- Continued work with MS/PhD student Jessica Conroy (leveraged by NSF fellowship funds) on the nature and mechanisms behind Southwest megadrought.
  - » Developed convincing evidence that the North Atlantic is much more important than previously thought, and at least as important as the tropical Pacific. A manuscript is nearing peer-review journal submission stage (Overpeck).

3.3 Explore potential hydrologic and land-cover impacts of climate change

- Continued work with colleague Jeremy Weiss on climate and biogeography of the Southwest. Working to detect and anticipate ecosystem change in the Southwest (Overpeck).

3.4 Improve understanding of connections between climate and public health

- The objective of this project is to use the Dynamic Mosquito Simulation Model (DyMSiM) to better understand and predict the dynamics of mosquito populations based on climate variability and change, especially mosquitoes responsible for transmission of disease, specifically West Nile virus and Dengue fever. Initial findings are below (Comrie).
  - » Mosquito sensitivity to warming and cooling
    - ◊ Warmer temperatures may reduce mosquito populations in a single area in the midsummer due to increased evaporation.
    - ◊ Warmer temperatures may extend the season in which mosquito populations can survive.
  - » Rainfall Patterns and Mosquito Populations
    - ◊ Occurrences of consecutive days of precipitation may be more important then total precipitation.
    - ◊ Large amounts of precipitation on a single day may yield spikes in mosquito populations, presumably because of resulting standing water.
    - ◊ Higher temperatures may reduce mosquito populations in a single area in the summer due to increased evaporation.
    - ◊ Higher temperatures may extend the season in which mosquito populations can survive.

4. Vulnerability

4.1 Assess community vulnerability through case studies

- Completed fieldwork in the Team Integrated Project (TIP) Area, which comprises portions of Arizona and New Mexico (Finan).
  - » Preparing a summary statement describing our findings on the livelihoods and climate vulnerability of the region.
  - » Preparing three papers drawing on findings in the project area, as well as a fourth comparing results obtained in current research with past projects of the Vulnerability Team.
- Team members Barbara Wolf, Marcela Vasquez-Leon, Tim Finan, and Don Anderson presented the results of previous case study, in the Upper Gila River Valley (completed in 2006) to area stakeholders including the San Carlos Apache Tribe and representatives from the Forest Service and the local ranching community. The presentation was held in San Carlos on the San Carlos Apache Reservation (Finan).
- Presented two case studies conducted by the vulnerability team at the annual meeting of the Society for Applied Anthropology (SfAA) in Tampa, Florida. Karen Pennesi presented a paper on livelihoods and climate change in the TIP area, and Marcela Vasquez-Leon presented on the relevance of ethnicity to climate vulnerability in the UGRV region (Finan).

4.2 Map vulnerability of the Southwest

- Climate Vulnerability Interactive Mapping Tool (CVIMT) is being refurbished. This decision-support tool incorporates GIS layers into an interactive web-based mapping program. The CVIMT permits users to zoom in and out, add and subtract layers, and view tabular data. Although still in the alpha-stage of development, interactions with stakeholder organizations indicate that it fills a need for easily accessible spatial data, and we expect that this will become a valuable tool for visualizing climate vulnerability, useful both for institutional decision-makers and the general public (Finan).

4.3 Assess economic impacts of drought and climate change on agriculture

- Updated and expanded the U.S. Agricultural Resource Model (USARM)
  - » With colleagues, updated and expanded the U.S. Agricultural Resource Model (USARM). For more information, see Tools, Model, Methods section below (Frisvold).

4.4 Assess economic impacts of climate variability on Southwest park recreation

- Developed and supervised contingent valuation surveys of visitors to Tumacacori National Historical Park and Tubac Presidio State Park (Frisvold)

» Data from the surveys will be used to estimate non-market value of the Upper Santa Cruz riparian corridor in Santa Cruz County, Arizona. Work was in collaboration with Tumacacori National Historical Park, Tubac Presidio State Park, Friends of the Santa Cruz River, and the Sonoran Institute.

Tools, Models, Methods

Dynamic Mosquito Simulation Model (DyMSiM) (Comrie)

This research is being conducted using dynamic modeling and Stella 9.02 simulation software. DyMSiM incorporates multiple elements affecting mosquito population developments, namely:

- Temperature dependent factors
  - » Egg, Larvae, and Pupae development rates
  - » Egg, Larvae, Pupae, and Adult survival rates
  - » Gonotrophic cycle
- Precipitation/Water dependent factors
  - » Larvae/Pupae capacity
  - » Egg hatching
  - » Egg laying
  - » Egg mortality
- Model modules and parameterizations of other environmental factors
  - » Land cover
  - » Land use
  - » Hours of daylight
  - » Evaporation rates
  - » Soil permeability
  - » Irrigation schemes

Model Validation: Validation of the *Cx. quinquefasciatus* model is near completion. Statistical analysis was done by comparing model output with mosquito count data in 25 location in Pasco County, Florida and 4 locations in Coachella Valley, California. Unfortunately, sufficient data to validate the *Aedes aegypti* model have not yet been identified in our searches to date, but we will continue to look for such data.

Future model development plans and potential applications:

- Multiple species: calibrate the model for other important mosquito species including other species in the *Culex* genus as well as Anopheles mosquitoes, which carry malaria.
- Model availability: potential transfer to other researchers and stakeholders through development of an Internet application.
- Model domain: spatial applications of the model to better understand the role of climate in spread and seasonality of these mosquito species across the US and possibly global domains.
- Model and GIS: incorporate model output into a GIS system to obtain spatial and temporal projections of mosquito populations, ultimately, over any designated area.
- Model and GARP: compare model output with prior GARP statistical modeling results.

Climate Variability – Winter Precipitation Anomalies (Comrie)

- Data:
  - » Monthly PRISM 4km gridded precipitation datasets, November–March (winter), 1896 – 2005.
  - » Monthly NARR gridded atmospheric data for November-March (winter), 1979-2005.
  - » Digital elevation map (DEM) of study area with 4km resolution.

- Methods:
  - » Created seasonal time-series of precipitation anomalies.
  - » Following Comrie and Glenn (1998), PCA (with varimax rotation) and maximum loading method were used to identify precipitation regions in the study area.
    - ◊ Three iterations performed to delineate sub-regions.
    - ◊ Derived time-series of the total precipitation for each region.
    - ◊ Pairs of adjacent sub-regions were identified. Calculated correlation for each adjacent pair of sub-regions. Least correlated adjacent sub-regions were selected for analysis within each region, as well as those across regions. Five pairs of sub-regions with greatest contrasts identified.
- Calculated time-series of z-scores of winter precipitation totals for each sub-region and determined differences between z-scores for adjacent pairs.
  - » Identified winters in which precipitation relationships between each sub-region pair diverged from seasonal normals.
    - ◊ Winters grouped into three "precipitation modes" based on the positive, negative or neutral values of their z-score difference.
- Calculated composites for each mode's PRISM and NARR variables
  - » Investigated synoptic and local-scale mechanisms affecting sub-regional precipitation.
    - ◊ Variables (at several levels) were analyzed for each sub-region pair, emphasizing four: (1) 300mb and 700mb geopotential height (GPH) anomalies (2) 700mb specific humidity (SPFH) anomalies (3) 700mb wind anomalies and (4) precipitation anomalies.

US Agricultural Resource Model (USARM) (Frisvold)

- USARM is a multi-region, 32-commodity mathematical programming model of the U.S. agricultural sector that accounts for price changes in national markets that farm-level or watershed-level models ignore. Other agricultural sector models focus on U.S. commodity program crops and exclude fruit and vegetable crops. In contrast, the updated USARM has comprehensive coverage of fruit and vegetable crops, which are important to Southwest agriculture.
- The model has been updated to be calibrated to more recent economic data (e.g. production, input use, and prices). More significantly, the structure and impacts of U.S. agricultural commodity programs has been more accurately modeled to capture interactions between climate shocks and agricultural policies. For example, farm program payments tied to market prices are not good at mitigating negative impacts of yield reductions and cost increases that drought brings.
- The updated USARM will be used to examine how a counter-cyclical payment system based on regional target revenues can be used to mitigate drought impacts. Countercyclical payments based on target revenues are components (on a pilot basis) of both House and Senate versions of the new Farm Bill.

Decision Support Tool and Scenario Development (Hartmann)

- Forecast Evaluation Tool (FET) http://fet.hwr.arizona.edu/ForecastEvaluationTool/
- Climate Information Delivery and Decision Support System (CLIDDSS)
- Automated Hydrologic Threshold Alert System (AHTAS) http://ursula.hwr.arizona.edu/StreamFlowTool/app
- Developed Scenario Development Framework in collaboration with SAHRA NSF Center. Framework identifies multiple types of scenarios, stages in scenario development and application, and offers approaches for linking integrated models with institutional planning and management processes. Website supports stakeholders in understanding scenario development and application (http://www.sahra.arizona.edu/scenarios).

Hydroclimatology and Paleohydrology for Decision Support (Hirschboeck)

- Flood Hydroclimatology Database
  - » Conceptualization of tools for using the dataset has begun. However, plans for the transfer of the flood hydroclimatology information as a tool on the Arizona Flood Warning and Drought Monitoring System (AFWS) website are on hold while logistics of the future location for the AFWS are resolved. The website is currently hosted by Salt River Project (SRP) but a move to Arizona Department of Water Resources (ADWR) is pending.

- Southwest TreeFlow Project—Updated Arizona Tree-Ring Streamflow Reconstructions for Decision Support
  - » An interactive method has been developed by UA Tree Ring Lab colleague Dave Meko for evaluating the probabilities of past low streamflow in comparison to different periods selected to represent the current drought. This tool was used at the preliminary results breifing with SRP to get their input on the base period to use for representing the current drought. Plans are underway to integrate this approach with other tools under development by CLIMAS investigator Holly Hartman.
  - » Tree-ring based hydroclimatic scenario products to use as tools in drought management planning are under development. These will be with integrated with tools for the entire West under a proposed cross-Risa Coping with Drought study.

Workshops, Media briefings, Stakeholder Presentations

Deborah Bathke

- With Connie Woodhouse and Jeff Lukas, convened a workshop on tree-ring based reconstructions for the Rio Grande Basin in Albuquerque on November 2, 2007. A summary of this workshop is posted at http://wwa.colorado.edu/resources/paleo/albuquerque_workshop.html.
- Conducted workshop to demonstrate AgClimate and solicit feedback on December 3, 2007 in Albuquerque for the Northern Extension District of New Mexio. Attended by 13 agents, the regional director, and the AgClimate team. We also discussed the types of climate information and decision-support tools the agents' thought would be most useful.
- Continued participation in the New Mexico Drought Monitoring Work Group. As the chair of this group, I publish a near monthly New Mexico Drought Status Report which is e-mailed out to numerous stakeholders and available via the Governor's Drought Task Force and New Mexico Climate Center websites.

Tim Finan

- Wolf, Barbara. 2007. "The Role of Climate in Water Conflict in the Upper Gila River Valley." Presentation given at the San Carlos Apache Reservation, March 28, 2007.

Daniel Ferguson

- With colleague Michael Crimmins (University of Arizona Cooperative Extension Climate Science Extension Specialist), conducted a climate needs assesssment survey at the Climate and Deserts Workshop: Adaptive Management of Desert Ecosystems in a Changing Climate, in Laughlin, Nevada (April 9-10, 2008). The needs assessment survey was designed to gain an improved understanding of how desert resource managers in the Southwest are currently using climate information, as well as to gauge climate information needs this group has that are not currently being met.

George Frisvold

- Frisvold, G. "Trends and Patterns in Irrigation Water and Energy Demand in Arizona." Presentation at the Southwest Hydrology & Arizona Hydrological Society 2007 Regional Water Symposium, Tucson, AZ, August 29-September 1, 2007.
- Frisvold, G. and J. M. Reeves "Trends in Water Conservation Among U.S. Cotton Producers." Presented poster, World Cotton Research Conference – 4, Lubbock, TX, September 10-11, 2007.
- Frisvold, G. "A Decision Model for Controlling Buffelgrass." USDA Program of Research on the Economics of Invasive Species Management (PREISM) Workshop. Washington, DC, October 18-19, 2007.
- Sprouse, T. and G. Frisvold. "Valuing Binational Effluent in Ambos Nogales." Seminar presentation at the Water Resources Research Center, Tucson AZ, November 28, 2007.

Gregg Garfin

- New Mexico Climate Change Adaptation. In September 2007, Garfin briefed three New Mexico audiences on potential climate change impacts to New Mexico water.
  - » 35 participants each briefing.

- In October 2007, Garfin co-organized, with collaborators at The Nature Conservancy, one of the nation's first meetings to focus on climate change impacts to state-level land and natural resources management. Overpeck served as keynote speaker. Experience with these processes led Garfin and AWI Director, Kathy Jacobs, to convene Arizona's first climate change water adaptation meeting, on Feb.4-5, 2008.
- City of Phoenix. In October, 2007, Garfin briefed City of Phoenix employees on climate change projections, observed and potential impacts.
  - » 30 participants.
- Quarterly online climate briefings for Arizona and New Mexico. In collaboration with Dr. Michael Crimmins (AZ Cooperative Extension), delivered three online, interactive briefings on recent climate and climate forecasts for the Southwest in 2007 and early 2008.
  - » 25 participants per briefing.
- Arizona Water and Pollution Control Association. In November, 2007, Garfin and Overpeck briefed senior Arizona water managers on climate change projections and impacts for Arizona. An article on their presentations will appear in the spring issue of the AWPCA newsletter.
  - » 30 participants.
- National Seasonal Assessment Workshops. Garfin co-organized two workshops to provide pre-season fire potential forecasts for the United States. For the Western U.S. meeting, Garfin organized participation by colleagues in Mexico, in order to promote timely exchange of cross-border fire information.
  - » 80 participants.
- Congressman Grijalva Briefing. Garfin, along with several UA scientists (incl. CLIMAS investigator Frisvold), briefed Congressman Raul Grijalva (D-Tucson) on climate change threats to Arizona's land and water resources, and advised the Congressman on strategic priorities for investments to protect Arizona resources and to mitigate impacts of climate change.
  - » 50 participants.
- Southwest Weather Symposium. Garfin co-organized meeting of scientists engaged in investigations of hydroclimatic forecasting and monsoon dynamics. Collaborators included National Weather Service, UA Department of Atmospheric Science, SAHRA, Davis-Monthan AFB, Vaisala, Inc. NWS Tucson was lead agency.
  - » 80 participants.
- On April 15, 2008, Garfin briefed the Gila River Indian Community Tribal Council on climate change and water issues for their lands.
- With CLIMAS co-investigators Deborah Bathke and Leeann Demouche (NMSU), Garfin co-convened stakeholder meetings in Roswell and Las Cruces, NM, in order to demonstrate the Southeast Climate Consortium's AgClimate decision support tool. The meetings (March 12-13, 2008) allowed our research team to build capacity for transfer and use of AgClimate in the Southwest, and to garner feedback on how to adapt AgClimate to meet New Mexico agriculturalists' needs. Holly Hartmann and Ellen Lay are also part of the CLIMAS team on this project.
- Garfin gave a keynote talk on climate change in the Southwest at the Climate and Deserts Workshop: Adaptive Management of Desert Ecosystems in a Changing Climate, in Laughlin, Nevada (April 9, 2008). In addition, Garfin convened an interactive session with conference participants, in order to garner information on decision contexts and climate information and adaptation needs for resource managers working in desert ecosystems. The workshop is part of a multi-year collaboration between CLIMAS and the University of Arizona Cooperative Extension.
- Garfin gave a presentation on efforts to develop a bi-national climate information product for northwest Mexico and the US-Mexico Border at the Regional Climate Forum for Northwest Mexico and the Southwest United States, 10-11 April 2008, in Ensenada, Baja California Norte, Mexico. Project co-investigators include Robert Varady and Chris Scott of the Udall Center for Studies and Public Policy, CLIMAS investigator Margaret Wilder, ISPE Deputy Director for research Barbara Morehouse, and several others. The Forum was convened by former CLIMAS postdoc Tereza Cavazos, who is now an investigator and faculty member at CICESE (Centro de Investigación Cientifica y de Educación Superior de Ensenada).

- With CLIMAS program manager Daniel Ferguson and CLIMAS PI Margaret Wilder, Garfin convened a 1.5 day meeting to brief the California Department of Water Resources on climate change issues along the US/Mexico border. The meeting was held in Tucson on April 1-2, 2008. Output from the meeting will be incorporated into materials to be considered at the 2008 Border Governors Conference. A special issue of the journal Climate Research is also being developed based on this meeting.

Holly Hartmann

Training

- Hydrologic Forecast Verification. River Forecast Center Verification Workshop, National Weather Service, Salt Lake City, UT, 14-16 August 2007.
- Scenario Assessment. Scenario Development and Applications Stakeholder Workshop, 2007 Regional Water Symposium and 20th Annual Meeting Arizona Hydrological Society, Tucson, AZ, 29 August 2007.

Presentations to Stakeholders (Public, Agencies)—all invited presentations

- Scenario planning: concepts and applications. Workshop on Scenario Planning for Climate Change in the National Park Service, National Park Service, Joshua Tree National Park, CA, 12-14 November 2008
- Reconciling projections of Colorado River flows. Third Research Coordination Network - Colorado River Delta Meeting, Oracle, AZ, 14-16 November 2007.

Workshop Co-organization and Facilitation

- Scenario Development and Applications Stakeholder Workshop, 2007 Regional Water Symposium and 20th Annual Meeting Arizona Hydrological Society, Tucson, AZ, 29 August 2007.
- ApplicationsWorkshop on Scenario Planning for Climate Change in the National Park Service, National Park Service, Joshua Tree National Park, CA, 12-14 November 2007.
- Scenario Analysis and Stochastic Hydrology for Water Resources. Session at Annual Meeting, American Geophysical Union, San Francisco, CA, 12-15 December 2007.

Katie Hirschboeck

- Technical Workshops on Tree-Ring-based Streamflow Reconstructions for Water Managers were held by CLIMAS affiliate Connie Woohouse (with Jeff Lukas) in Boulder CO; Durango CO, Cheyenne WY and Albuquerque NM. At the workshops in Boulder (May 14, 2007) and Albuquerque (Nov 2, 2007) stakeholder partner Charlie Ester of Salt River Project gave a presentation illustrating how the Hirschboeck-Meko project results from the LTRR-SRP I partnership are currently being used by SRP in water management. See: http://wwa.colorado.edu/resources/paleo/workshops.html
- Dave Meko & Katie Hirschboeck presented a briefing on preliminary findings for their LTRR-SRP II project to the Salt River Project Water Resources Operations staff at SRP in Phoenix Arizona on November 27, 2007.
- Participates in the bi-monthly meetings of the AFWS-MATF in Phoenix.
- Katie Hirschboeck & Dave Meko presented their final results of their LTRR-SRP II project to the Executive Management of Salt River Project (see: http://www.srpnet.com/about/officers.aspx) at SRP in Phoenix Arizona on February 26, 2008. A follow-up workshop presentation of the project's final results was given to Phoenix area water managers at SRP in Phoenix on April 28, 2008. Stakeholders in attendance at this workshop were city water managers from the Phoenix metropolitan area including: Phoenix, Scottsdale, Mesa, Tempe, Chandler, and the East Valley Water Forum (EVWF), as well as attendees from SRP, the National Weather Service, the US Bureau of Reclamation, the Central Arizona Project, and ASU's Decision Theater.
- Hirschboeck, with colleagues Mike Crimmins (University of Arizona Cooperative Extension Climate Science Extension Specialist), and Theresa Crimmins (University of Arizona Office of Arid Lands Studies) facilitated an 8-session outreach program designed to communicate climate change science to faith-based communities called "God's Creation Cries for Justice -- Climate Change: Impact and Response" These sessions were held in Tucson Feb 28 – May 1, 2008. (pdf available at: http://www.justfaith.org/Attachments/PDFs/JustMattersClimateChangeFlyer.pdf).

Jonathan Overpeck

Presentations

- August, 2007 – Invited Speaker, 2007 Regional Water Symposium: "Sustainable Water, Unlimited Growth, and Quality of Life: Can We Have It All?", Tucson, AZ
- September, 2007 – Invited Speaker, Border Institute-IX: Security, Development and the Environment at the U.S.-Mexican Border.
- October, 2007 – Invited Evening Speaker on Climate Change, Public Forum Co-sponsored by The Nature Conservancy and the University of Chicago, Chicago, Illinois.
- October, 2007 – Invited Speaker - New Mexico Climate Change Ecology and Adaptation Workshop, Albuquerque, New Mexico.
- October, 2007 – Invited speaker, series of three lectures sponsored by the State Engineer of New Mexico, Albuquerque and Santa Fe, New Mexico.
- October, 2007 – Invited Evening Speaker, Arizona Association for Environmental Educators conference, Tucson, Arizona.
- October, 2007 – Invited Speaker, Department of Soil, Water and Environmental Sciences, University of Arizona, Tucson.
- October, 2007 – Invited Speaker, Water Policies and Planning in the West: Ensuring a Sustainable Future, Western Governors' Association and the Western States Water Council, Salt Lake City, UT.
- November, 2007 – Invited Speaker and Panel Member, Climate Change and the Role of Higher Education in Arizona: Preparing our Students for a Changing World, Phoenix, AZ.

Press

- August 24-29, 2007 – Interviewed for KUAT-FM Arizona Spotlight on subject of water sustainability; also was the guess for a 1-hour live talk-radio segment on KVOI-AM, and a shorter interview on KJLL-AM, both focused on the same topic.
- September, 2007 – Featured in story on Arizona climate change and the Western Climate Initiative in the Havasu News-Herald (Arizona)
- September, 2007 – Featured in story on university campus sustainability in the Arizona Daily Star.
- October 22 , 2007 – Featured along with Vice President Gore in NPR program "U.N. Panel Shares Nobel with Gore". Also, featured in multiple newspaper stories around Arizona for sharing Nobel Peace Prize for role as a Coordinating Lead Author in the IPCC Fourth Assessment.
- November, 2007 – Featured in History Channel documentary "'A Global Warning'.
- November 18, 2007 – Featured in front-page story on climate change in the San Francisco Chronicle
- December 28, 2007 – Featured in climate change and La Niña story in the Arizona Republic
- December 29, 2007 – Featured in story about California climate change in an AP story

Margaret Wilder

- Wilder participated in a collaborator/stakeholder workshop entitled "Communities, Conservation and Climate Change in the Lower Rio Colorado and Delta Binational Region," April 28, 2008 Tucson, AZ.
- Wilder was an invited speaker for two presentations at the University of Redlands in Ontario, Califrornia:
  - New Geographies of Environmental Governance: Communities, Conservation and Climate Change in the Colorado Delta and Border Region. May 15, 2008.
  - How Does the Public Fit In? Climate Change, Adaptation and Social Stakeholders in the Southwest US and Northwest Mexico. May 16, 2008.

Links with Other NOAA Programs

- Earth System Research Laboratory
- High Plaines Regional Climate Center (HPRCC)
- NOAA Paleoclimatology Program/NESDIS-NCDC

- NWS Climate Prediction Center
- NWS Climate Services Division/Office of Weather, Water, and Climate Services
- NWS Office of Hydrologic Development
- NWS River Forecast Centers
- NWS Weather Forecast Offices (Albuquerque, Flagstaff, Las Vegas, Phoenix, Tucson)
- NWS Western Region Headquarters
- Pacific Region Integrated Data Enterprise (PRIDE) and Integrated Data and Environmental Applications (IDEA) Center
- RISAs: CISA, SECC, WWA, CIG, CAP
- Scripps Experimental Climate Prediction Center
- Southern Regional Climate Center
- Western Regional Climate Center

Cross RISA Activities

Coping with Drought Cross RISA Projects in 2007

- Reconciling projections of future Colorado River stream flow (with CAP, WWA, CIG, Dept. Interior Bureau of Reclamation, NOAA National Weather Service, and Geophysical Fluid Dynamics Laboratory, and Dept. Agriculture Natural Resources Conservation Service)
- Reducing New Mexico's agricultural drought vulnerability through stakeholder assessment and climate decision support (with Southeast Climate Consortium, SECC)
- Index and Impact Tools to Improve Drought Monitoring and Preparedness (with Carolinas Integrated Sciences Assessment, CISA)
- Tree-Ring Reconstructions of Hydroclimatic Variability in the Rio Grande Basin, New Mexico Intra-CLIMAS Collaboration (with Western Water Assessment, WWA)

Other Cross RISA Collaborations

- Collaboration on National Seasonal Assessment Workshops (CAP and WWA).
- Collaboration on California Department of Water Resources decision support (CAP and WWA).
- Provided feedback about Climate Change Adaptation Guidebook based on work with stakeholders (AHS, NPS), use of adaptation guidebook in NPS scenario planning framework assessment efforts (CIG).
- Active participation on RISA Executive Committee (Overpeck and Hartmann).
- Overpeck and Connie Woodhouse co-advising PhD student Cody Routson (WWA)
- Graduate student Jennifer Rice (UA Geography) is collaborating with CLIMAS and WWA on evaluation projects

Peer Reviewed Publications

Frisvold, G. and K. Emerick. 2008. Rural-Urban Water Transfers with Applications to the U.S. Mexico Border Region. In *Game Theory and Policy Making in Natural Resources and the Environment.* A. Dinar, J. Albiac, and J. Sanchez-Soriano (eds.). New York: Routledge Press.*

* *Information from this study was communicated to water managers from California, Arizona, New Mexico, and Texas at the Climate Change Adaptation for Water Managers Workshop, Biosphere 2, Oracle, Arizona February 5, 2008*

Garrick, D., K. Jacobs, G. Garfin. 2008. Models, Assumptions, and Stakeholders: The Case of Colorado River Water Supply Planning. *Journal of the American Water Resources Association* (accepted for publication; April 2008 issue).*

* *Information from this study was communicated to US Bureau of Reclamation.*

Hirschboeck, K.K. (in press) Flood flows of the San Pedro River Basin. In *Ecology of Desert Riparian Ecosystems: The San Pedro River Example*. Julie Stromberg and Barbara Tellman (Eds). Tucson: University of Arizona Press.

Neff, J. C., A. P. Ballantyne, G. L. Farmer, N. M. Mahowald, J. L. Conroy, C. C. Landry, J. T. Overpeck, T. H. Painter, C. R. Lawrence, and R. L. Reynolds. 2008. Increasing eolian dust deposition in the western United States linked to human activity. *Nature Geosciences* 1 (3):189-195.

Pineda Pablos, N., A. Browning-Aiken and M. Wilder. 2007. Equilibrio de bajo nivel y manejo urbano del agua en Cananea, Sonora. *Frontera Norte*. 19 (37).

Ray, A.J., G. M. Garfin, M. Wilder, M. Vásquez-León, M. Lenart, A. C. Comrie. 2007. Applications of Monsoon Research: Opportunities to Inform Decision Making and Reduce Regional Vulnerability. *Journal of Climate*. 20 (9): 1608-1627.

Stewart, S., M. Mahmoud, Y. Liu, H. Hartmann, T. Wagener, and H. Gupta. 2007. Scenario development for water resources planning and management. In *Changes in Water Resources Systems: Methodologies to Maintain Water Security and Ensure Integrated Management*. N. van de Giesen, X. Jun, D. Rosbjerg and Y. Fukushima (Eds). Wallingford, UK: International Association of Hydrological Sciences, IAHS Publ. 315, pp.192-198.

Tamerius, J., Wise, E.K., Uejio, C.K., McCoy, A., and Comrie, A.C. 2007. Climate and human health: Synthesizing environmental complexity under uncertainty. *Stochastic Environmental Research and Risk Assessment*. 5:601-613.

Wilder, M. (in production). Equity, Privatization and Reforms: Water and Small Farmers in Mexico. In *Water and Equity: Apportioning Water Among Places and Values*. Richard Perry, Helen Ingram, and John Whiteley (Eds). Cambridge, MA: Massachusetts Institute of Technology (MIT) Press Series on American and Comparative Environmental Politics and Policy.

Non Peer-reviewed Publications and Presentations

Coles, A. 2008. Managing Flash Floods: Risk Perception from a Cultural Perspective. Annual Association of American Geographers meeting, Boston, MA. April 15-19, 2008.

Coles, A.R. 2007. Perhaps our science is only as good as society's willingness to use it. Weather and Society Watch, 1(3): 5, 8. http://www.sip.ucar.edu/news/pdf/Weather_and_Society_Watch_042007.pdf

Coles, Ashley. 2007. Theory for the Flood Risk from a Cultural Perspective. Presentation at American Water Resources Association Meeting in November 2007.

Coles, Ashley. 2007. Theory for the Flood Risk from a Cultural Perspective. Presentation at Southwest Hydrometeorological Symposium in September 2007.

Diaz Caravantes, Rolando. 2008. Water for the Environment and Local Livelihoods in the Context of Drought: A Case Study from Northern Mexico. Paper presented at the Association of American Geographers Annual Meeting, April 15-19, 2008, Boston, MA.

Emerick, Kyle. 2007. Upstream Market Power in Water Transfers" Department of Agricultural & Resource Economics. Master's Thesis, University of Arizona. (G. Frisvold, thesis advisor)

Ferguson, Daniel. How did we do? Initial results from a pilot CLIMAS stakeholder evaluation project. Presentation at Climate Prediction Application Science Workshop. Chapel Hill, North Carolina, March 4-7, 2008.

Garfin, Gregg. RISA Regional Drought Knowledge Transfers: Southeast/Southwest. Presentation at Climate Prediction Application Science Workshop. Chapel Hill, North Carolina, March 4-7, 2008.

Garfin, G, Lenart, M, 2007. Overview of Climate Change Effects on Southwest Water Resources. Southwest Hydrology 6(1): 16-17, 34.

Garfin, G. 2007. Assessment of the Navajo Nation Hydroclimate Network final report. http://www.u.arizona.edu/~gmgarfin/awi-nn_report.pdf.

Garrick, D., K. Jacobs, and G. Garfin, 2008. Models, assumptions, and stakeholders: planning for water supply variability in the Colorado River basin. Journal of the American Water Resources Association, 44(2), 381-398.

Hartmann, Holly. 2008. Supporting Climate Change Adaptation in US National Parks through Scenario Planning. Presentation at Climate Prediction Application Science Workshop. Chapel Hill, North Carolina, March 4-7, 2008.

Hartmann, H.C., 2007. Decision support for water resources management. CCSP SAP 5.1, Uses and Limitations of Observations, Data, Forecasts, and Other Projections in Decision Support for Selected Sectors and Regions. US Climate Change Science Program.

Hartmann, H. 2007. Decision support tools: strategies for effectively linking hydroclimatic science and society. Office of Arid Lands Seminar Series, University of Arizona, Tucson, 22 August 2007.

Hirschboeck, K. 2008. Co-organizer of Cross-RISA Panel: Taking the "Voodoo" out of Science: Improving Stakeholder-Science Communications. Association of American Geographers Annual Meeting, Boston, MA. April 15-19, 2008.

Hirschboeck, K. 2008. Invited Panelist on "Exploring future research gaps: Water resources, climate change, and world regions." Association of American Geographers Annual Meeting, Boston, MA. April 15-19, 2008.

Lay, Ellen. 2007. Climate information delivery and decision support system (CLIDDSS). Presentation at Pacific Region Data Integration and Visualization Workshop, Honolulu, HI, 16-18 October 2007.

Morehouse, B., G. Frisvold, and R. Bark. 2007. How Can Recreation and Tourism Benefit from Multi-disciplinary Approaches to Assess and Adapt to Climate Change? Lessons from the U.S. Southwest. Paper presented at the 3rd International Workshop on Climate, Tourism, and Recreation, Alexandroupolis, Greece, September 19-22, 2007.

Morin, C. and A. Comrie. 2008. A West Nile Virus Vector's Response to Climate Variability using the Dynamic Mosquito Simulation Model (DyMSiM). Annual Meeting of the Association of American Geographers, Boston, MA, April 15-19, 2008.

Morin, C.W. and A. Comrie. 2007. Development of the dynamic mosquito simulation model (DyMSiM). Presentation at the Seventh Symposium on the Urban Environment, American Meteorological Society, San Diego, California, September 10-13, 2007.

Novak, Rachael. 2007. Climate Variability and Change in the Chuska Mountain Area: Impacts, Information, and the Intersection of Western Science and Traditional Knowledge. Masters Thesis, Geosciences, University of Arizona.

Tamerius, J. and A. Comire. 2008. Sub-Regional Winter Precipitation Variability: Case studies of disparate winter precipitation modes in Southwest U.S. Annual Meeting of the Association of American Geographers, Boston, MA, April 15-19, 2008.

Tamerius, J. 2007. Sub-regional winter precipitation variability in the southwest US: A study of contrasting precipitation anomalies. Master's Thesis, Geography, University of Arizona (Comrie, thesis advisor).

Vasquez-Leon, Marcela, Barbara Wolf, Colin T. West, and Don Anderson. 2007. Water is Life: A Community-Level Assessment of Climate Vulnerability in the Upper Gila River Valley. CLIMAS Report.*

* *Information from this study was communicated to San Carlos Apache Tribe and other local stakeholders.*

Wilder, M. 2007. Just Add Water: Implications for Privatization, Sustainability and Development in Mexico's Ejido Sector. Presentation at Latin American Studies Association (LASA), Montreal, Québec, September 5, 2007.

Wilder, M. 2008. From Geopolitics to Local Practices: Conservation, Climate Change and Local Communities in the Binational Colorado River Delta. Presentation to University of Arizona Department of Geography Colloquium. February 15, 2008.

Wilder, M. 2008. The Environment for Water: 21st Century Transitions in Mexican Water Policy and Implications for Sonora. Paper presented at the Rocky Mountain Council of Latin America Studies Annual Meeting, April 11, 2008, Flagstaff, Arizona.

Wilder, M. 2008. New Geographies of Climate Change and Environmental Governance on the Mexico-U.S. Border: Institutions, NGOs and Local Communities in the Binational Colorado River and Delta Region. Paper presented at the Association of American Geographers Annual Meeting, April 15-19, 2008, Boston, MA.