

ANNUAL PROGRESS REPORT
Climate Assessment for the Southwest (CLIMAS) Project
For Funding Year 2001-2002

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Submitted to
Harvey Hill, Regional Integrated Science and Assessment Program (RISA)
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VULNERABILITY ANALYSIS

Team Members: Timothy Finan, Diana Liverman (co-investigators), Marcela Vásquez-León (postdoc), Colin West, Jane Moody, Barbara Wolf (RAs)

Rural Livelihoods. A second case study, which focused on groundwater-dependent agriculture in the Sulphur Springs Valley area of Southeastern Arizona, was completed and a report was drafted. The report is being published as part of the CLIMAS report series in Fall, 2002.

We coordinated with the Core Office to initiate outreach activities to members of the community, through participation in the annual Southeastern Arizona Agriculture Day and Trade Show held in Sulphur Springs Valley, Arizona each February. This was an integrated effort that included the members of the vulnerability assessment team as well as Gregg Garfin and Barbara Morehouse from the Core Office and Holly Hartmann and Tom Pagano from the forecast team. Activities included inviting participants to participate in a user test of the newly developed CLIMAS web site and of the forecast evaluation web tools maintained on the HyDIS web site, as well as informal conversations.

This coming year we will start our third case study focusing on surface water irrigated agriculture and tourism in the Safford/San Carlos Apache Reservation. We will also begin work on the vulnerability map. We have already done a preliminary visit to the study site and are collecting relevant data and historical information.

Border Vulnerability Analysis. Due to the appointment of Diana Liverman as Interim Dean of the UA College of Social and Behavioral Sciences, work on border-area research had to be deferred. This research will be reactivated during the 2002-2003 budget period.

Publications

Eakin, H and J Conley. 2002. Climate variability and the vulnerability of ranching in southeastern Arizona: a pilot study. *Climate Research* 21(3): 271-281.

Finan, TJ, CT West, D Austin, and T McGuire. 2002. Processes of adaptation to climate variability: a case study from the U.S. Southwest. *Climate Research* 21(3): 299-310.

Liverman, DM and R Merideth. 2002. Climate and society in the US Southwest: the context for a regional assessment. *Climate Research*: 21(3): 199-218.

Vásquez-León, M, CT West, B Wolf, J Moody, T Finan. 2002. Vulnerability to Climate Variability in the Farming Sector: A Case Study of Groundwater Dependent Agriculture in Southeastern Arizona. CLIMAS Report xx, Institute for the Study of Planet Earth. University of Arizona, Tucson, Arizona. Forthcoming.

Vásquez-León, M, CT West, TJ Finan (submitted). Assessing vulnerability to climate: agriculture and ranching on both sides of the US-Mexico border. *Global Environmental Change*.

West, CT. 2001. Testing farmers' perceptions of climate variability with meteorological data: Burkina Faso and the Sulphur Springs Valley, Arizona. Masters thesis. Tucson: University of Arizona.

West, CT. and M. Vásquez-León (in press). Testing farmers' perceptions of climate variability: a case study from the Sulphur Springs Valley, Arizona. *In* (eds.) B. Orlove and S. Strauss, *Weather, Climate, Culture: Building Anthropological Bridges from Past to Future*, Berg Publishing: New York.

Vásquez-León, M. and D. Liverman (submitted) Assessing land-use/cover change: the case of affluent ranchers and destitute farmers in the Mexican Municipio of Alamos. *Human Organization*.

Presentations

Finan, TJ. 2002 Vulnerability and adaptation to climate change and variability: the emergent anthropological agenda. Paper presented at the Society for Applied Anthropology Meetings. Atlanta, Georgia.

Vásquez-León, M. 2001. Assessing vulnerability to climate risk: the case of affluent ranchers and destitute farmers in Sonora, Mexico. Paper presented at the Open Meeting of the Human Dimensions of Global Environmental Change Research. Rio de Janeiro, Brazil Oct 6-8, 2001.

West, CT. and M. Vasquez-Leon. 2002. Testing farmers' perception of climate variability: a case study from the Sulphur Springs Valley, Arizona. Paper presented at the 13th Conference on Applied Climatology. Portland, Oregon.

Wolf, B. 2002. The impact of institutions on perceptions of vulnerability to climate change in the Southwest US. Paper presented at the Society for Applied Anthropology Meetings. Atlanta, Georgia.

Vásquez-León, M. 2002. Assessing vulnerability to climate risk: the case of small-scale fishing in the Gulf of California, Mexico. Paper presented at the Society for Applied Anthropology Meetings. Atlanta, Georgia.

INSTITUTIONAL AND POLICY ANALYSIS

Team Members: Maria Carmen Lemos, Barbara Morehouse (co-investigators), Melissa Hart (RA)

San Pedro River Basin Study. The institutional analysis of the use of water resources in the US-Mexico San Pedro River Basin was initiated in Feb 2001. An open ended, in-depth questionnaire focusing on climate information and decisionmaking in the context of both the San Pedro Partnership and environmental actors in Mexico was applied. The goal of the research is to understand how stakeholders use climate products by examining their models of decision making. We focus on the ability of different groups to incorporate innovation and the constraints and opportunities to change decision models.

The results of this research are to be published in the master thesis of a CLIMAS assistant researcher to be concluded in the Fall of 2002. The scope of this research is being expanded to other areas of the Southwest including the Tucson-Phoenix area and Yuma in 2002.

The institutional analysis and policy team worked on documenting processes of interactive research and co-production of knowledge and policy in the context of CLIMAS. The results of this research are the subject of an article co-authored by Maria Carmen Lemos and Barbara Morehouse to be submitted for publication in the Fall of 2002.

Urban Water Study. We have completed all tasks initiated during CLIMAS Phase I. The final tasks, publishing the results of the policy analysis and survey of water providers, are now finished. Additional work on urban water and climate is being initiated in Phase 2, through the Master's thesis work of a CLIMAS Research Assistant. The project takes a political ecology approach to examining the impacts on water resource management on interactions of climate, economic growth, and demographic change. Flagstaff, Arizona is the case study site for this work.

Publications

Carter, RH and BJ Morehouse. 2002. Vulnerability and Climate Information Use among Urban Water Providers. CLIMAS Report Series CL2-XX, Institute for the Study of Planet Earth, The University of Arizona, Tucson, Arizona. (forthcoming).

Carter, RH and BJ Morehouse. 2001. An examination of Arizona water law and policy from the perspective of climate impacts. CLIMAS Report Series CL2-01, Institute for the Study of Planet Earth, The University of Arizona, Tucson, Arizona.

Gamble, JL, J Furlow, AK Snover, AF Hamlet, BJ Morehouse, H Hartmann, T Pagano. (forthcoming). Assessing regional water resources: the implications for stakeholders of climate variability and change. In (eds.) D Fort and R Lawford, *Science and Water Resource Issues: Challenges and Opportunities*. American Geophysical Union.

Morehouse, BJ. 2002. Integrating climate into water policy. *Southwest Hydrology* 1(2): 16-17, 28.

Morehouse, BJ. 2001. Can Tucson's water supply survive a drought on the Colorado River? *WaterWords* 19(1).

Morehouse, BJ, RH Carter, and P Tschakert. 2002. Sensitivity of urban water resources in Phoenix, Tucson, and Sierra Vista, Arizona to severe drought. *Climate Research* 21(3): 283-297.

Varady, R and BJ Morehouse. (in review). Moving borders from the periphery to the center: river basins, political boundaries and water management policy. In (eds.) D Fort and R Lawford, *Science and Water Resource Issues: Challenges and Opportunities*. American Geophysical Union.

Presentations

Morehouse, BJ. 2001. Is there a place for climate information in water policy? Insights from Arizona. Paper presented at the Annual Meeting of the American Water Resources Association, Albuquerque, NM, November 12-15, 2001.

HYDROLOGY AND FORECASTING

Team Members: Roger Bales, Soroosh Sorooshian (co-investigators), Holly Hartmann (research scientist), Tom Pagano, Kristie Franz (RAs)

Evaluation of Seasonal Water Supply Forecasts from Ensemble Forecast Procedures

We worked with the NWS Office of Hydrologic Development (OHD) and the Colorado Basin River Forecast Center (CBRFC) to implement the NWS ensemble stream flow prediction (ESP) Verification System (ESPVS) and used it to conduct a hindcast-based evaluation for 14 headwater locations in the Colorado River Basin. It was found that using a single trace prediction, such as the median, resulted in a loss of valuable forecast information. ESP forecasts proved to be a more accurate prediction of future stream flow when compared to climatology forecasts and on average provide useful information about the likelihood of future stream flow magnitude with lead times of up to seven months. At the longest lead times, while the ESP forecasts could not indicate which conditions were *most* likely, they could indicate which conditions were *least* likely – a type of information not available in current operational forecasts and not previously appreciated by the NWS RFC forecasters. At shorter lead times the forecasts become sharper and provide predictions of future stream flow likelihoods with high reliability and good discrimination. The evaluations also showed the need for improved modeling of the Verde River system; the system is poorly modeled, but the one most frequently used by the Salt River Project to provide water resources management flexibility for central Arizona water supplies. The forecast evaluation approach highlighted the importance for forecasting agencies to archive information associated with production of their operational forecasts, as well as the need to use a range of forecast evaluation methods to establish forecast credibility or to identify areas requiring improvement. At the request of the NWS, we have received additional funding to examine the practicality of applying the forecast evaluation procedures to a broad range of hydrologic forecasts (see leveraged research projects, below).

Incorporation of Climate Outlooks into Seasonal Water Supply Outlooks. We have been working to adapt the regression-based water supply forecast procedures to incorporate climate forecasts in a way that reflects the past skill of those climate forecasts, which varies by region and forecast period. A total of 24 headwater locations throughout the U.S. West were selected, in conjunction with the CBRFC and the Natural Resources Conservation Service (NRCS) National Water and Climate Center (NWCC). Regression equations for all 24 watersheds were calibrated using operational water supply forecasting software, climate division precipitation and temperature data, and Niño 3.4

and PDO climate indices, among others. Hindcasts from these equations will be used as baseline forecasts as well as to assess the relative improvement available from use of simple climate indices. A linear discriminant analysis approach has been used to develop a 30-year time series of climate forecasts that mimic the behavior of climate forecasts issued by the NWS Climate Prediction Center (CPC) since 1995 when the CPC forecasts took on their present form. These pseudo-CPC forecasts are then used to create regression equations for water supply forecasts using existing NRCS and CBRFC procedures. Other procedures are also being considered, including use of regression equations within an ESP framework and weighting of ensemble traces. Prospects for rapid incorporation of demonstrably improved techniques have been increased through the hiring by the NRCS of Tom Pagano as the water supply forecaster for the Southwest.

Forecast Evaluation: Developing Customizable Internet-based Forecast Evaluation Tool

We have been developing an Internet-based interactive forecast evaluation tool that decision makers can customize to their specific interests. Earlier stakeholder interactions made clear that long-term acceptance of the web tool by resource managers as a useful system to support decision making required significant commitment to development of a “commercial quality” website, which represents a departure from the mission of CLIMAS. To address this issue, we began a partnership the NASA-funded project Hydrologic Data and Information System (HyDIS) project and a NOAA OGP-funded project under the GEWEX America Prediction Project (GAPP) (see leveraged projects, below). Coordination with these projects brought into play a software engineering approach to achieve reliable support of multiple simultaneous users on a variety of browsers with Internet connections of moderate speed. The approach required expert Web programmers to develop Java-based tools and implement a system for managing incremental website enhancements. Development of the web tool allows customization of evaluations for discussing other issues. A rapid prototype, used for controlled demonstration of the interactive forecast evaluation and interpretation tools, was completed in December 2001 and has subsequently been presented in a variety of settings. The prototype allows evaluation of CPC probability anomaly map forecasts for the 102 CPC-defined regions covering the conterminous U.S. Evaluation criteria include some based on contingency tables and categorical forecasts (Probability of Detection and False Alarm Rate) and others that provide summary measures of probabilistic forecast performance (Brier Score and Ranked Probability Score). The web tool includes a tutorial and an extension suggested by stakeholders that helps place the forecasts in a regional historical context that includes long-term and recent observations. The demonstration web site may be found at http://hydis2.hwr.arizona.edu/synergy/climas_FET_Presentation/ It requires Netscape 6.2 and the Java plug-in.

Interactions with stakeholders during the forecast evaluation tool demonstrations confirmed that it is an ideal platform for enhancing understanding of seasonal forecasts and discussing issues associated with seasonal probabilistic forecasts, their use, and accommodation of uncertainty. Interest in the online tool was uniformly greater than we expected. Indeed, after the prototype demonstrations many individuals wanted personal access to the website. However, comments from stakeholders suggested that websites under development (e.g., with broken links, segments that are down) can result in frustration and poor credibility. Thus, we decided on a staged release of the forecast

evaluation tool, whereby individuals could sign up as beta-testers for the first “commercial quality” version, to be followed later by an open release.

Additional Research Activities. Some progress was made in two additional areas, although further progress awaits new staffing: (a) a preliminary assessment of hydrologic variability in the Southwest, was compiled, including a review of the physical forces driving that variability, particularly snow pack accumulation and depletion; and (b) a preliminary assessment of the Berkeley Regional Climate Model’s predictive skill for snow conditions was performed. As part of this latter effort, a preliminary database of spatio-temporal winter precipitation and snow pack conditions was created in conjunction with the NASA Regional Earth Science Applications Center at the UA Department of Hydrology and Water Resources.

Publications

Franz, KJ. 2001. Evaluation of National Weather Service ensemble streamflow prediction water supply forecasts. Masters Thesis, Department of Hydrology and Water Resources, The University of Arizona, Tucson, AZ.

Franz, KJ, HC Hartmann, S Sorooshian, and R Bales. 2002. Evaluation of Colorado River Basin Ensemble Streamflow Predictions, 82nd Annual American Meteorological Society Annual Meeting, Orlando, Florida, January 2002, 16th Annual Conference on Hydrology, J109-J112.

Hartmann, HC. 2002. Guest editorial - Better communication with decisionmakers: focus on forecasts. *Weatherzine*, June issue.

Hartmann, HC. 2001. Stakeholder driven research in a hydroclimatic context. PhD dissertation, Department of Hydrology and Water Resources, University of Arizona, Tucson, Arizona.

Hartmann, HC., R. Bales, and S. Sorooshian, 2002. Weather, climate, and hydrologic forecasting for the U.S. Southwest: a survey. *Climate Research* 21:239-258.

Hartmann, HC and TC Pagano. 2001. How good are climate forecasts? Interpretive Handout, Department of Hydrology and Water Resources and CLIMAS, Institute for the Study of Planet Earth, University of Arizona, Tucson, AZ, 18pp.

Hartmann, HC., TC Pagano, S. Sorooshian, and R. Bales. 2002. Confidence builders: evaluating seasonal climate forecasts from user perspectives. *Bulletin of the American Meteorological Society* 83(5):683-698.

Hartmann, HC, TC Pagano, and S Sorooshian. 2002. How good are seasonal climate forecasts? *The Climate Report*, winter issue.

Pagano, TC. 2002. Student editorial - Life as an interdisciplinary scientist: am I being set up? *Weatherzine*, May issue.

Pagano, TC., HC Hartmann, and S. Sorooshian. 2002. The role and usability of climate forecasts for water management in Arizona: a case study of the 1997-98 El Niño. *Climate Research* 21:259-269.

Pagano, TC, HC Hartmann, and S Sorooshian. 2001. Use of climate forecasts for water management: Arizona and the 1997-98 El Niño. *Journal of the American Water Resources Association* 37(5):1139-1152.

Presentations

Franz, KJ. 2002. Evaluation of ensemble streamflow predictions for the Colorado River Basin. 12th Annual El Dia Del Agua, Department of Hydrology and Water Resources, University of Arizona, Tucson, AZ, April 12, 2002.

Franz, KJ. 2001. Evaluation of NWS ensemble streamflow predictions. National Weather Service Hydrologic Forecasting Workshop, Colorado Basin River Forecast Center, Salt Lake City, UT, September 12, 2001.

Franz, KJ, HC Hartmann, S Sorooshian, and R Bales. 2002. Evaluation of Colorado River Basin ensemble streamflow predictions. 16th Conference on Hydrology/82nd Annual Meeting, American Meteorological Society, Orlando, FL, January 13-17, 2002.

Franz, KJ, HC Hartmann, S Sorooshian, and R Bales. 2001. Evaluation of ensemble streamflow predictions for the Colorado River Basin. NOAA Science Advisory Board Meeting, Tucson, AZ, November 6, 2001. (poster).

Hartmann, HC. 2002. Fostering use of advanced predictions in water resources applications: integrations between RISAs and GAPP. Mississippi River Climate and Hydrology Conference, GEWEX Continental Intercomparison Project and GEWEX Americas Prediction Project, New Orleans, LA, May 13-17, 2002.

Hartmann, HC, TC Pagano, K Franz, S Sorooshian, and R Bales. 2002. Evaluating the uncertainty of probabilistic predictions: techniques, applications and implications. EOS, Transactions of the American Geophysical Union, Spring Meeting Supplement, Abstract H42E-01, Washington, DC, May 29 – June 3, 2002.

Hartmann, HC, TC Pagano, and S Sorooshian. 2002. Online interactive seasonal forecast evaluations: a tool for improving water resources management. Mississippi River Climate and Hydrology Conference, GEWEX Continental Intercomparison Project and GEWEX Americas Prediction Project, New Orleans, LA, May 13-17, 2002.

Hartmann, HC, TC Pagano, and S Sorooshian. 2002. Customized on-line climate forecast evaluations: a tool for improving water and watershed management. 10th Conference on Agricultural, Range, and Aviation Meteorology, American Meteorological Society, American Meteorological Society, Portland, OR, May 13-16, 2002 .

Hartmann, HC, TC Pagano, Bales, R, and S Sorooshian. 2001. Stakeholder driven research: the CLIMAS experience. EOS, Transactions of the American Geophysical Union 82(20), Spring Meeting Supplement, Abstract H21C-06, Boston, MA, May 29, 2001.

Hartmann, HC, W Thomas, and TC Pagano. 2001. Science and policy: what scientists need to know about government. Departmental Seminar Series, Department of Hydrology and Water Resources, University of Arizona, Tucson, AZ, September 5, 2001.

Imam, B and HC Hartmann. 2002. Tools and user requirements for improved access to hydrologic information. Seminar series, NOAA Climate Diagnostics Center, Boulder, CO, April 11, 2002.

Pagano, TC, Hartmann, HC, and S Sorooshian. 2002. Introduction to forecast evaluation. Departmental Seminar Series, Department of Hydrology and Water Resources, University of Arizona, Tucson, AZ, March 13, 2002.

Demonstrations of Prototype Online Forecast Evaluation Tool

- ◆ NOAA Science Advisory Board, Tucson, AZ, 6 November 2001
- ◆ Louis Ucellini, Director National Centers for Environmental Prediction, Tucson, AZ, December 4, 2001
- ◆ NOAA OGP RISA Project Managers, Tucson, AZ, December 2001
- ◆ Predictive Services Research Conference, National Interagency Fire Center, Boise, ID, 23 January 2002
- ◆ Southeastern Arizona Agriculture Day and Trade Show, Willcox, AZ, February 6, 2002
- ◆ Experimental Climate Prediction Center, Tucson, AZ, February 12, 2002
- ◆ National Science Foundation Science and Technology Center on the Sustainability of Semi-Arid Hydrology and Riparian Areas (SAHRA), Tucson, AZ, February 28, 2002, Climate Diagnostics Center, Boulder, CO, April 11, 2002

Other Activities

H. Hartmann: Geographic Area Coordination Center (GACC) Meteorologist Training, National Interagency Fire Center (NIFC), Ft. Collins, CO, 10 April 2002. At the invitation of NIFC, the online forecast evaluation tool was used as the basis for a 2-hour workshop on understanding seasonal climate forecasts and how GACC meteorologists can use climate forecasts to support decisions made by regional wildland fire managers.

H. Hartmann, with M. Marino (University of California – Davis), organized special session, “Communicating Scientific Consensus in Hydrologic Science”, Fall Meeting, American Geophysical Union, San Francisco, CA, 10-14 December 2001.

H. Hartmann, with R. Lawford (NOAA OGP), organized special session, “Science and Water Resource Issues: Challenges and Opportunities”, Spring Meeting of the American Geophysical Union, Boston MA, 29 May – 2 June 2001. This session is serving as the

basis for an AGU monograph by the same name, to be co-edited with R. Lawford and D. Fort (School of Law, University of New Mexico).

Leveraged Projects

Soroosh Sorooshian, Holly Hartmann, and Tom Pagano were selected by the AMS to serve as the independent judges for a climate forecast contest sponsored by Aquila Energy Corporation. Over 85 contestants (from universities, agencies, etc.) compete for \$50,000 each season by making the best seasonal temperature forecasts for 13 cities throughout the United States. This project will allow CLIMAS to begin research on combining multiple probabilistic forecasts and expert opinions.

Soroosh Sorooshian and Holly Hartmann were also awarded a 3-year research grant under the GEWEX America's Prediction Project (GAPP). The grant is closely linked to ongoing CLIMAS activities, but focuses on providing specific tools for the more effective and rapid transition of advanced seasonal predictive capabilities into water management decision processes.

Holly Hartmann has been working closely with the NASA- and Raytheon-funded Hydrologic Data and Information System (HyDIS) project. HyDIS is expected to provide important services for the CLIMAS project, through the development of a user-customizable Internet portal for hydroclimatic data, analysis routines, and report generation capabilities. It is expected that HyDIS will eventually serve as a key avenue for providing tools to stakeholders that support their decision processes.

Soroosh Sorooshian and Kristie Franz received a grant from the NWS Office of Hydrologic Development to evaluate the requirements for applying probabilistic forecast evaluation procedures used in CLIMAS research to evaluate other operational ESP forecasts that have been generated by the NWS, including water supply, peak flow, mean flow, and precipitation forecasts. The goal of this research is not only to evaluate the forecasting accuracy of operational ESP forecasts, but also to inform the NWS of what forecast information must be archived in order to implement the evaluation procedures at all NWS River Forecast Centers. It is anticipated that this project will expedite the integration of a comprehensive and consistent evaluation procedure into the NWS forecasting system.

CLIMATE VARIABILITY – PALEO

Team Members: Malcolm Hughes (co-investigator), Fenbiao Ni (postdoc)

Accessible Paleoclimatic Resource. We have completed our work on divisional reconstructions of cool-season precipitation back to AD 1000. A paper reporting these has been accepted for publication and should appear shortly (Fenbiao Ni et al, in press). This details 1000-year long tree-ring based reconstructions of cool season precipitation for each of the climate divisions of Arizona and New Mexico, and includes a comparison of two methods of producing these reconstructions. The reconstructions are now available for inclusion in products aimed at stakeholders.

Gridded Reconstruction of Summer PDSI. Our 2 by 3 degree gridded reconstruction of summer PDSI back to AD 1000 is nearing completion. The PDSI reconstructions are available and two products are close to completion. The first is a paper that will report both the PDSI reconstructions and the gridded winter precipitation reconstructions planned to be completed in the first months of the 2002-2003 year (Hughes et al., in preparation). The second product is a web presentation of these reconstructions being developed in collaboration with the NOAA Paleoclimatology program in Boulder, Colorado, specifically with Ed Gille and Mark McCaffrey. The presentation allows the user to generate maps of the reconstructions for individual years or groups of years as well as to download time series from specified grid points. The reconstructions cover the Four Corners states, California and Nevada and part of Oregon. The plan is to permit display of side-by-side annual maps of reconstructions and instrumental data for the last century, in turn permitting a direct comparison of current conditions of interest to the end user with conditions at other times in the last millennium. The website will also provide access to calibration and verification statistics as well as explanatory materials.

Decadal to century-scale variability and its impact on interannual predictability in the region. This work is nearing completion. We have prepared a manuscript in which we discuss the feasibility of reconstructing major circulation indices from the tree-ring data for this region.

PDO Research. We commenced a major activity, substantially based on collaboration with the other western RISAs, and organized jointly with Nate Mantua of the University of Washington, to use paleo data to examine Pacific Decadal Variability and the implications for our regions. On November 9, 2001, 23 scientists met for a workshop at the University of Washington in Seattle and agreed on a short-term plan to pool data and expertise. Their aim is to construct the best possible history of the 1976-type transitions, technically known as the “Pacific Decadal Oscillation” or PDO, covering the last several centuries. The data to be used will be from places as far afield as Alaska, Patagonia, and coral islands in the Pacific. In the first instance, the participants will pool their data according to an agreed procedure, and then will be free to pursue different approaches to characterizing these patterns over the last few centuries. It is hoped that this will engender friendly rivalry and stimulate creativity in devising the best approach. Although we must view these records in the very large context of what happens over the whole Pacific Basin, our main goal is to get a better understanding of the predictability of climate in Western North America. Since the November meeting, a considerable body of data has been submitted to Dr. Fenbiao Ni, who is acting as data coordinator, and has been prepared for distribution to the members of the group. The first attempts at analysis will be made in summer 2002.

Publications

Ni, F., T. Cavazos, MK Hughes, AC Comrie, and G Funkhouser. Cool Season Precipitation in the Southwestern United States since AD 1000: Comparison of Linear and Nonlinear Techniques for Reconstruction. *International Journal of Climatology*

Hughes, MK, G Funkhouser and F Ni. Spatial reconstructions of winter precipitation and summer drought since AD 1000 in the Western United States. In preparation.

Hughes, MK, F Ni and G Funkhouser. Reconstructed atmospheric/ oceanic indices since AD 1000 from tree rings in Western North America. In preparation.

Presentations

Hughes, MK and G Funkhouser. 2001. Frequency-dependent climate signal in upper and lower forest border trees in the mountains of Great Basin. Invited speaker, *HIGHEST II conference*, Davos, Switzerland, June 24-28, 2001.

Hughes, MK, F Ni and G Funkhouser. 2001. ENSO and decadal teleconnections in western North America during recent millennia. Invited speaker, *Open Science Meeting of International Geosphere-Biosphere Program*, Amsterdam, Netherlands, July 9 – 13, 2001.

Hughes, MK. 2001. ENSO and decadal teleconnections in western North America during recent millennia. Invited *Seminar*, *University of Bern*, Switzerland, September 20, 2001.

Ni, F, MK Hughes and G Funkhouser. 2001. Atmospheric and oceanic indices since ad 1000 reconstructed from tree rings in the American Southwest. Poster presented at *International Conference on Tree Rings and People*, Davos, Switzerland, September 22-26, 2001.

Hughes, MK, F Ni, and G Funkhouser. 2001. Interannual to millennial climate fluctuations recorded in old Western trees. Talk presented to UA Laboratory of Tree-Ring Research, November 1, 2001.

Sheppard, PR, AC Comrie, GD Packin, K Angersbach, and MK Hughes. 2002. The climate of the US Southwest. *Climate Research* 21(3): 219-238.

CLIMATE VARIABILITY – RECENT

Team Members: Andrew Comrie (co-investigator), Korine Kolivras, David Brown (RAs)

Valley Fever Project. We wound up our Valley Fever work, and developed a scoping paper on climate and health in the CLIMAS region. This exercise provided the framework for evaluating the relative merits of new climate-health research in our region. We plan to begin work on air quality and climate questions in the next funding year.

Development Of Fine-Scale Gridded Data. We completed winter-climate grids and continued our ongoing work on operationalizing a download interface to serve the data on our web site. Specifically, we completed winter temperature and precipitation datasets for the 1961-1999 winter season, at a 1 X 1 km grid scale. We are continuing our work on baseline-modeled climatologies at a monthly scale.

Climate Variability Analysis. Although not funded during the 2001-2002 budget year, we have continued our studies on the nature and causes of climate variability. We continue to be engaged in the following inquiries: (a) subregional climate variability, including

relationship between precipitation and climate teleconnections; (b) relationship between urban growth in Phoenix, Arizona and monsoon precipitation; (c) climate drivers of spring season precipitation, which is the primary wildland fire season in the Southwest; (d) spatial and temporal patterns, as well as causes and controls, of heavy monsoonal precipitation events.

Publications

Brown, DP and AC Comrie. (submitted). Subregional seasonal precipitation linkages to SOI and PDO in the Southwest United States. *Atmospheric Science Letters*.

Brown, DP and AC Comrie. 2002. Spatial modeling of winter temperature and precipitation in Arizona and New Mexico, USA. *Climate Research* 21(3).

Kolivras, KN and AC Comrie. (submitted). Modeling valley fever incidence based on climate conditions in Pima County, Arizona. *International Journal of Biometeorology*.

CLIMAS Web pages on climate and health; CLIMAS web pages on asthma and climate.

Presentations

Brown, DP and JE Diem. 2002. An urban-induced summertime moisture signal in central Arizona. Paper presented at the Annual Meeting of the Association of American Geographers, Los Angeles, California, March 20-23, 2002.

Comrie, AC and DP Brown. 2002. Development and analysis of fine-scale gridded climate data for Arizona and New Mexico. Paper presented at the 13th Conference on Applied Climatology, American Meteorological Society, Portland, Oregon, May 13-16, 2002.

Comrie, AC and DP Brown. 2001. Subregional variability of winter climate in Arizona and New Mexico. Paper presented at the 26th Annual Climate Diagnostics and Prediction Workshop, La Jolla, California, October 22-26, 2001.

Kolivras, KN and AC Comrie. 2002. Exploring links between climate and influenza outbreaks. Presentation to the Annual Meeting of American Geographers, Los Angeles, California, March, 2002.

Kolivras, KN and AC Comrie. Presentations at summer and fall cocci (valley fever) research group meetings.

CORE OFFICE

Barbara Morehouse (co-investigator), Jonathan Overpeck (Director, ISPE), Gregg Garfin (postdoc), Shoshana Mayden (web designer), Rebecca Carter, Tamara Wilson (RAs)

Web Site. We have redesigned and reorganized the CLIMAS web site. The new web site, <http://www.ispe.arizona.edu/climas>, features improved content, including summaries of CLIMAS research projects, improved navigation, improved and reorganized links, including text summaries of links content, an online bibliography of literature relating to fire and climate, improved educational material, improved and expanded Southwest Climate Outlook (now monthly). As part of this process, we conducted a literature review on communicating complex scientific information via the Internet, and on the process of testing Web-based materials for usability. The results of the usability test have been documented for internal reference, and we plan to put the literature review on the CLIMAS web site.

Stakeholder Outreach. On February 7, 2002, together with team members representing the forecast and vulnerability assessment groups, we set up a poster display and two interactive laptop workstations at the Southeastern Arizona Agriculture Day and Trade Show. CLIMAS received valuable feedback about our forecast evaluation research and our revised web site from stakeholders in the agriculture and ranching sectors. Moreover, we established stronger ties with Arizona Cooperative Extension and the Natural Resources Conservation Service. Based on interest in our presentations, we were accepted an invitation to hold a small workshop on March 11, 2002, for Southeastern Arizona farmers and ranchers in order to educate the stakeholders about CLIMAS activities and the CLIMAS forecast evaluation tool. We will continue outreach efforts with along these lines during the coming year.

The Core Office continues to publish a quarterly newsletter, which, with the help of our publication-and Web-designer, has been redesigned to have a more professional look. The Core Office, with the assistance of the Udall Center, continues to maintain a relevant stakeholder address database and mailing list for publications and announcements.

Fire and Climate Meeting Coordination and Organization. The CLIMAS Core Office held its annual CLIMAS fire-climate workshop, entitled Fire in the West (2002), in early spring 2002. This workshop involved collaboration with the Program for Climate, Ecosystem, and Fire Applications (CEFA) at the Western Regional Climate Center, the Institute for the Study of the Planet Earth, the Laboratory of Tree-Ring Research, and the National Weather Service Tucson Weather Forecast Office. The meeting was funded by ISPE, NOAA, the Joint Fire Sciences Program, and the USDA Forest Service.

The meeting featured two research symposia and a session of climate forecast talks, along with a breakout session to identify data needs and fruitful areas for future research. One symposium focused on cutting-edge fire-climate research on a variety of topics ranging from smoke management to continental-scale fire history reconstructions. The second focused on the human dimensions of fire management and highlighted efforts by fire management agencies to engage community members living at the urban-wildland interface in forward-thinking fire management practices.

Fire in the West also included two sessions in which climate forecast and fire management experts produced fire season climate and fuels forecasts. In one session, climate forecast experts from CPC, CDC, IRI and Scripps combined the results of their various forecast models to create a March-August 2002 national climate forecast

specifically tailored to a format suggested by fire managers present at the meeting; this forecast has been made available via the web. In a second session, fire intelligence officers from the Southwest Coordination Center, CEFA and the National Interagency Coordination Center combined information from the national climate forecast with fuels assessments for Arizona and New Mexico, made by workshop participants, and created a forecast of fire season conditions for the Southwest (also available on the web).

As a result of our workshops, outreach to the fire management community, and presentations at national meetings, CLIMAS was invited by the National Interagency Coordination Center Predictive Services Unit to bring together fire management professionals and climate forecasters from each of the Geographic Area Coordination Centers (GACCs) to produce fire season outlooks. CLIMAS will work with CEFA and NICC Predictive Services to coordinate this activity and to create protocols and procedures that will enable the GACCs to produce their own monthly forecast updates.

We edited and published a proceedings volume from the 2001 fire-climate meetings, which was distributed to over 300 fire managers and climate scientists across the country. Editing of the 2002 fire-climate proceedings is currently underway.

Project Coordination. The Core Office continues to maintain two listservs (one for the larger interested community and one for CLIMAS team members). We also continue to hold team meetings, Postdoc meetings and PI meetings and work to ensure that CLIMAS team members participating relevant meetings, conferences, and other such events. Another important task is assuring that team members maintain open communications with each other and with the Core Office. The Core Office also continues to ensure that working papers are completed, given internal review, and transferred to our web site in a timely fashion. In May 2001, Gregg Garfin attended the U.S. Global Change Research Program Data and Information Working Group (DIWG) workshop "Gaining Knowledge from Environmental Data." Information gained at the workshop has improved CLIMAS understanding and coordination of metadata from research projects and has provided us with insights into the communication of complex scientific information and usability testing of Web-based research products.

We produced, in collaboration with team members, the CLIMAS proposal to NOAA-OGP for the next 5 years. The proposal was submitted in August 2001.

In November 2001, CLIMAS principal investigators and postdoctoral researchers came together for an innovative two-day retreat. The focus of the retreat was to identify the main points and results of the first three years of CLIMAS research and to draft papers for peer-reviewed publication that synthesize the main thrust of CLIMAS research. The five research papers begun at the retreat are now close to completion. CLIMAS investigators hope that these papers will lay a solid theoretical and experiential foundation for a proposed National Climate Service.

Network Building. The Core Office has been working with a wide variety of agencies in order to coordinate communication about integrated climate assessment research and to develop a solid network of partners and research collaborators. During the past year, CLIMAS maintained contact with the following agencies: Arizona Cooperative Extension; Arizona State Office of Climatology; University of Arizona-Raytheon Hydrological Data and Information System (HyDIS); New Mexico Drought Task Force;

National Interagency Coordination Center Predictive Services; NOAA-CIRES Climate Diagnostics Center; NOAA Climate Prediction Center (Southwest drought monitoring; Pacific tropical storm forecasts); NWS Tucson Forecast Office; NOAA Pacific Northwest Climate Impacts Group; NOAA Three-States Water Management and Climate Information Project; USGS Earth Surface Processes Team; Western Regional Climate Center; NOAA Western Water Assessment; NOAA California Applications Project, NOAA Office of Atmospheric Research; the NSF Science and Technology Center for Sustainability of semi-Arid Hydrology and Riparian Areas (SAHRA).

Gregg Garfin met, in May, 2001, with members of the NOAA Western Water Assessment and the NOAA Three-States Water Management and Climate Information Project. These informal meetings improved flow of information between the projects and opened avenues of communication regarding future RISA activity in New Mexico.

We co-organized, with NOAA and in close collaboration with the Climate Diagnostics Center, a workshop in Tucson to explore the human dimensions of the proposed North American Monsoon Experiment (NAME). The workshop took place June 18-20, 2002. Representatives of all CLIMAS task groups participated in the meeting. Andrea Ray has drafted proceedings from the workshop; revision of the proceedings is underway.

CLIMAS hosted a visit in December 2001 by Dr. David Goodrich, while he was serving as director of the NOAA Office of Atmospheric Research. Meetings with Dr. Goodrich provided CLIMAS with an opportunity to showcase some of our research and to provide him with suggestions about how we think a National Climate Services operation might be structured, as well as what specific services might be offered.

In January 2002, Gregg Garfin and Holly Hartmann were invited to visit the National Interagency Coordination Center (NICC) in Boise, ID, in order to brief senior national and regional fire managers about the array of research, product development, and workshop activity being conducted by that CLIMAS. At the meeting, Gregg Garfin and Tom Wordell (NICC) initiated a plan to work together, with Tim Brown of CEFA, on creating a 2003 workshop for regional fire management coordinators (see *Fire and Climate Meetings*, above)

El Niño-Drought Initiative: Beginning in February 2002, CLIMAS began planning for summer implementation of an initiative to provide information to a selected group of stakeholders about drought conditions in the Southwest, and the progress of the El Niño event forecasted for winter 2002-2003. The project will incorporate insights from research on the use of El Niño information by water managers conducted by team member Tom Pagano, as well as insights from NOAA's California El Niño pilot project conducted by Claudia Nierenberg and Katie Mastriani. The process will include holding regular press meetings with a variety of partners, including SAHRA and the National Weather Service and coordinating a Southwest drought monitor reporting group with partners from the Arizona and New Mexico State Climatologist offices, the National Weather Service, Natural Resources Conservation Service and SAHRA. Insights from the Southwest will be communicated to the Western Regional Climate Center and National Drought Monitor scientists at NOAA's Climate Prediction Center. We will also conduct a monthly survey of our selected group of stakeholders to monitor their

perceptions, determine their needs for information, and assess the effectiveness of the information on the format of the information that we provide them.

Publications

Garfin, GM and BJ Morehouse. 2001. Facilitating use of climate information for wildfire decision-making in the U.S. Southwest. *Proceedings of the Fourth Symposium on Fire and Forest Meteorology, 13-15 November 2001, Reno, Nevada*. Boston, American Meteorological Society.

Garfin, GM and BJ Morehouse (eds.). 2001. Proceedings, 2001 Fire & Climate Workshops, February 14-16, 2001 and March 28, 2001, Tucson, Arizona. Institute for the Study of Planet Earth.

Morehouse, BJ. 2002. An integrated approach to evaluating climate impacts in the southwestern US. *The Climate Report* 3(1): 2-5.

Other Publications

CLIMAS web site content and graphics

CLIMAS Update Newsletter (quarterly)

Presentations

Brown, T. and BJ Morehouse. 2002. Climate, fire and society in the western United States. Paper presented at the Annual Meeting of the Association of American Geographers, Los Angeles, CA March 19-23, 2002.

Garfin, GM. 2002. Climate Variability and Fire Management in the U.S. Southwest. 98th Annual Meeting of the Association of American Geographers (AAG), Los Angeles, CA, March, 2002.

Garfin, GM. 2002. Climate information and wildfire decision-making in the Southwest. National Interagency Coordination Center Predictive Services meeting, Boise, Idaho; January 23, 2002.

Garfin, GM. 2001. Facilitating use of climate information for wildfire decision-making in the U.S. Southwest. 4th AMS Symposium on Fire and Forest Meteorology, Reno, Nevada; November 13-15, 2001.

Garfin, GM. 2001. The CLIMAS: Climate Assessment for the Southwest. Tucson Hot Topics Cool Solutions 2001 Exposition, Tucson, Arizona; September 10-11, 2001.

Garfin, GM, BJ Morehouse, and TW Swetnam. 2001. CLIMAS climate and fire management studies. 18th Pacific Climate Workshop (PACLIM), Pacific Grove, California; March 18-21, 2001.

Garfin, GM, 2001. CLIMAS: An integration of science, community, and policy. BIA Western Regional Forestry and Natural Resources Meeting. Camp Verde, Arizona; March 6, 2001.

Morehouse, BJ. 2002. Paper presented at the Third Symposium on Environmental Applications: Facilitating the Use of Environmental Information, Annual Meeting of the American Meteorological Society, Orlando, FL January 2002.

Morehouse, BJ, GM Garfin, M Vasquez Leon, H Hartmann, T Pagano, KL Kolivras, F Ni, T Finan, DM Liverman, A Comrie, R Bales, S Sorooshian, MK Hughes, JT Overpeck, D Austin, and D Hadley. 2002. Structuring climate services through stakeholder-driven assessment. 2002. Climate and wildfire. Presentation to climate forecasters, NOAA Climate Prediction Center, January 2002.

Overpeck, JT, SK Avery, and BJ Morehouse. 2002. Regional Climate Services: Research Perspectives and Mechanisms for Communication. Paper presented at the Third Symposium on Environmental Applications: Facilitating the Use of Environmental Information, Annual Meeting of the American Meteorological Society, Orlando, FL January 2002.

Other Activities

BJ Morehouse gave, at the invitation of D LeCompte, a presentation at the Climate Prediction Center forecasters on our fire-climate research.

GM Garfin and BJ Morehouse co-organized special session on “Society, Fire, Climate and Ecosystems in North America” at the 98th Annual Meeting of the Association of American Geographers (AAG), Los Angeles, CA, March 19-23, 2002.

B Morehouse conducted a discussion of cultural aspects of the southwestern monsoon in October 2001. The discussion was part of a semester-long seminar was held under the auspices of the UA dendrochronology program.

T Finan and B Morehouse co-taught a graduate seminar during Spring semester, 2002, on the use of vulnerability assessment in the context of global change. The seminar is a required course for the PhD Minor in Global Change offered at UA.

HF Diaz and BJ Morehouse contracted with Kluwer to publish the book they are coediting, *Climate and Water: Transboundary Challenges in the Americas*. Final edits are underway; the book will be published in 2003.