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1. INTRODUCTION

In the semi-arid Southwest, climate is an implicit, yet often unacknowledged, element of decision-making processes in water and resource management. Based on advances in our understanding of quasi-periodic shifts in ocean-driven persistence in the climate system (e.g., ENSO, NAO, PDO), our ability to monitor and predict variations in water variability has increased remarkably during the past decade. There has been a concomitant increase in the value to society of information about climate variability and change.

Recent advocacy by the National Drought Policy Commission (2000) for adoption of a national drought policy highlights the extent to which awareness of and concern about climate impacts has increased. Yet, as noted by Nicholls (1999) and others, cognitive illusions and use of inappropriate heuristics often hamper effective use of climate information in decision making. At the same time, due to the inherent uncertainties involved, climate prediction remains somewhat suspect in the eyes of many potential users (Sarewitz et al. 2000). Through END InSight, and a related initiative to provide climate information within the Upper San Pedro Basin, which spans the US-Mexico border (discussed below), we seek to "narrow the range of possible futures so that decision making can be more successful" (Pielke, Jr. et al. 2000: 367). The success in the Southwest of the 1997-98 El Niño predictions, as well as the subsequent winter's La Niña prediction, provides us with a foundation for engaging stakeholders in the region in this somewhat broader exploration of the wide array of climate information products that are currently available or that can be relatively easily developed. In undertaking this effort, we hope to contribute not only to improving communications with stakeholders at the regional and local levels, but also to demonstrating some of the ways in which a formal climate services operation might disseminate rapidly evolving climate information in ways that directly serve public needs. As recognized by the Board on Atmospheric Sciences and Climate has observed, "a climate service must focus on very different types of activities in order to address all of the major categories of variability and change.... Each [service and product] is associated with different types of users or decision makers and with different types of needs and products...." (National Research Council 2001:1).

Beginning July 2002, the NOAA-funded Climate Assessment for the Southwest (CLIMAS) project embarked on a year-long initiative (called END InSight) to provide monthly packets of climate information to a selected group of regional stakeholders, including water resource managers. The hydroclimatic focus of the

initiative is the El Niño forecasted for 2002-03 and the severe drought currently gripping the Southwest. The approximately 40 participants are being given a short questionnaire with each packet to fill out and return to CLIMAS. In the questionnaire, participants are invited to evaluate each of the pieces of information they receive in terms of the information's utility, ease of interpretation, provision with appropriate lead time, level of detail, and graphic design. They are also invited to indicate whether or not they actually used the information provided and if so, how. The data collected under the END InSight initiative will serve several purposes: (a) provide improved understanding of the degree of convergence between information available and information needed among stakeholders in the US Southwest; (b) gather comments and suggestions that may be useful in developing or improving forecast and information products; and (c) providing guidance to forecast and information providers in researching and developing better and more useful products.

A related and interconnected initiative is also underway to improve the flow of climate information between forecasters and stakeholders in the Upper San Pedro River watershed. The river and its watershed, which spans the US-Mexico border, is located in the northwestern corner of Sonora and southeastern corner of Arizona. Currently funded by the Netherlands-based Dialogue on Water and Climate (DWC), a group of researchers from the University of Arizona and UNAM in Mexico City are working to develop a combined set of US and Mexican information useful to local watershed residents and stakeholders on both sides of the border. This paper provides a mid-course progress report on the two interrelated projects, and the implications for provision and use of climate information in water resource management.

2. END InSight STAKEHOLDERS

In order to garner feedback most appropriate for the establishment of an operational Climate Service in the Southwest, stakeholders were chosen from a wide variety of decision-making and information use livelihoods throughout Arizona and New Mexico (Table 1). Water resource managers in rural and urban areas, as well as decision makers for whom precipitation and water availability are critical factors (e.g., land managers and agriculturalists) are well represented in our sample. These stakeholders are representative of an array of jurisdictional interests (Table 2). While fairly broad-based, we note our sample does not sufficiently

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represent stakeholders in Western Arizona and Eastern New Mexico (i.e., outside of Albuquerque and Santa Fe).

Table 1. Stakeholder livelihoods.

Sectors	
Agricultural extension	7
Community development	1
Emergency management	1
Environmental assessment	3
Fire management	3
Land/wildlife management	11
Media	3
Power management	1
Range management	2
Tourism	2
Urban water management	2
Water resource management	7
Total	43

Table 2. Stakeholder jurisdictions.

Jurisdiction	
County	6
Federal	13
Municipal	2
Non-Governmental Organization	5
Private	7
State	7
Tribal	3
Total	43

3. END InSight CLIMATE INFORMATION PACKETS

The full-color climate information packets have been designed to meet the following objectives: (a) provide a summary of recent conditions, (b) provide monthly and seasonal forecasts for a variety of basic and applied climate variables, (c) provide background and education on a variety of hydroclimatic topics of relevance to the Southwest. Information provided in the packets is always approached from the viewpoint of links to drought on multiple timescales and to interactions with or impacts generated by El Niño.

Information on recent conditions includes examinations of temperature, precipitation, drought indices and drought status and reservoir levels on timescales from the most recent months to the entire past year. Forecasts include monthly and seasonal temperature and precipitation forecasts, drought index and seasonal drought outlook forecasts, fire, hazards and El Niño forecasts. Streamflow forecasts and snowpack measurements will be added beginning January, 2003.

Background and education is provided in two ways, through a monthly newsletter and through pages devoted to particular phenomena or new ways of measuring climate and climate impacts (e.g., floods, PDO, tropical storms, interpretation of climate forecasts, Standardized Precipitation Index, etc.). The background pages often feature original research by CLIMAS or combinations of published and (as yet) unpublished

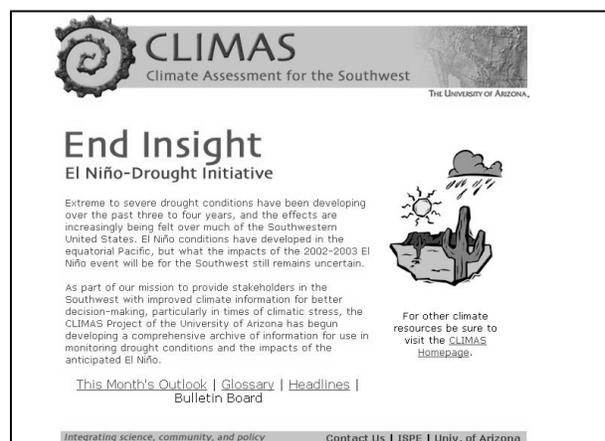
studies by colleagues and research partners, such as National Weather Service forecast offices and the NOAA-CIRES Climate Diagnostics Center.

In addition to the featured graphic (e.g., CPC seasonal precipitation forecast) each page contains (a) a *notes* section with caveats about data limitations and information on how to interpret the graphics, (b) a *highlights* section with interpretation of the graphics and ancillary information based on related reports, and (c) *links* to source material web pages. Each month, a cover letter, highlighting novel information and responses to stakeholder concerns, is included. An executive summary, which highlights recent conditions and synthesizes a variety of forecasts, is also included in each monthly packet.

4. END InSight Web Site

The material included in each monthly packet forms the nucleus of the END InSight web site (<http://www.ispe.arizona.edu/climas/end/>) (Figure 1). In addition to the packet material, the web site features an up-to-date glossary of hydroclimate terminology, text summaries and links to full text of selected newspaper articles about issues relevant to the project, and links to PDF files containing each monthly packet. The latter has allowed us to distribute information more informally to a wider audience of interested parties who found out about the project by word of mouth. These unofficial participants provide informal comments and feedback. The END InSight web site also allows us to provide ancillary information, and to expose participants to alternative forecasts and climate analysis products. In addition, the web site allows us to provide greater depth and length of explanation for background topics, and direct links to a wider variety of source material web sites.

Figure 1. END InSight Web Page.



5. END InSight PRESS BRIEFINGS

In conjunction with research partners (e.g., NOAA-CIRES CDC; NWS Weather Forecast Offices) and synergy projects (SAHRA, the NSF Science and Technology Center for sustainability of semi arid

hydrology and riparian areas; HyDIS, the NASA-Raytheon hydrological data and information system), the CLIMAS END InSight project hosts regular press briefings in Albuquerque, Phoenix and Tucson. The press briefings provide print, radio and television journalists with up-to-date and accurate information regarding drought status, long-range climate outlooks, El Niño forecasts, and hydroclimate-related impacts on water supply and land management resources.

The key messages of the press briefings have been (a) the great historical variability of El Niño impacts, (b) reliability of long-range forecasts and limits to predictability, and (c) the variety of timescales in which drought operates and the persistence of hydrological drought long after average or above average precipitation returns to the region. These press briefings provide journalists with an opportunity to focus on long-term and persistent hydroclimatic impacts and phenomena (e.g., water supply, streamflow, drought), in contrast to the more short-term and sensational meteorological events (e.g., severe storms, floods) that tend to dominate public awareness.

6. END InSight SURVEYS

In July 2003, stakeholders received the first of our information packets. During this initial month they received an extensive initial stakeholder information survey, which sought answers to questions about access to communication and computer technology, major climate-related concerns of the participants' organization, the participants' position and field of expertise, and sources of hydroclimatic information regularly consulted by the participant. Beginning with the July 2003 packet and continuing for one year, participants receive and answer two brief surveys, as follows: (a) an overall evaluation of whether the information provided had an influence on the participants' organization, whether they shared information from the packet with co-workers or others, and whether any important information was lacking; and (b) and evaluation of each page in terms of adequacy of lead time, amount of detail, ease of understanding, graphic style, and whether the participants took any action based on the information provided.

5. END InSight PRELIMINARY RESULTS

Most of our participants (80%) prefer to receive information at least monthly, and 33% would like updates more frequently. 44% of participants require information at 1 season or longer lead time prior to making a decision, whereas 29% can act if provided with information 1-3 weeks in advance of decision making. These time scales indicate that most participants can use climate-scale information in decision making at lead times consistent with the release of hydroclimatic forecasts.

The majority of participants have thus far found drought-related products useful, whereas only 4%-6% of participants (depending upon the product) have found these products not useful. The products include the

U.S. Drought Monitor, current PDSI status, precipitation needed to bring PDSI to *normal*, and PDSI forecasts provided by the National Drought Mitigation Center. Between 33%-50% of participants indicated that they have, thus far, taken actions based on information contained in the drought graphics (Table 3).

Table 3. Responses regarding drought products.

Product	% finding product useful	% taking action based on product
U.S. Drought Monitor	83	44
Current PDSI	78	38
Precipitation necessary to bring PDSI to <i>normal</i>	81	40
Precipitation required to end or ameliorate drought	77	50
PDSI Forecast	77	33

The majority of participants (64%-84%) have thus far found the NOAA Climate Prediction Center monthly and seasonal temperature and precipitation outlooks useful. Given the ongoing drought and the need for information about water and precipitation in the semiarid Southwest, it is not surprising to find that fewer participants find the temperature outlooks useful. The relatively low percent of action taken with regard to precipitation outlooks might have to do with the lack of summer season forecasts (i.e., "CL" forecasts), and the relatively low confidence expressed in the small probability shifts forecasted thus far for winter 2002-2003 precipitation.

Table 3. Responses regarding CPC forecast products.

Product	% finding product useful	% taking action based on product
CPC 1-Month and 1-Season Temperature Outlook	68	43
CPC Multi-Season Temperature Outlook	64	32
CPC 1-Month and 1-Season Precipitation Outlook	81	39
CPC Multi-Season Precipitation Outlook	84	39

Responses to open-ended survey questions and comments regarding individual climate information products for the first two months of the project confirm that information has been useful for decision making, particularly for agriculturalists and land managers. The following comments (which have been adjusted to protect participant anonymity) give examples:

- "Will circulate information to staff. Info will/may be useful to adjust watering schedule for pronghorn antelope and alert status for

potential danger to undocumented alien traffic across the (area)."

- "Multi-season outlook provides some insight for our (area) prescribed burn program, with the predicted chance for above average precipitation we may have to adjust the timing of some of our burns."
- "Revised and accelerated monitoring plan for spring persistence and flow. Removed bag limit for warm water fish in a very low pond, and postponed any planning to stock trout until possibly mid-winter, if rains are indeed greater than average. Planned further water hauling to frog pond."
- "From previous packet, found that (*distant area*) has had rain - called to check for possible pasture for our herd - but info was too late to give us a "jump" - available pasture was already taken and he's had 30 phone calls!"
- "Used in discussion with local growers for making management decisions...great information - look forward to next packet."
- "Plan to send out packets to county agents as I travel along the (*river valley*) working with water issues this month."

Some participants have provided concise feedback regarding the graphical limitations of some products; for example,

"While useful in general, the interpolated (*temperature and precipitation from regional data provider*) maps concern me because of a risk that they may be taken too literally. It's important to remember we don't really know what's happening in between the points where measurements are taken. For this reason, we shy away from using them in (*publication*)."

"Colors are difficult to discern...and (*regarding climate division maps provided by drought diagnostic agency*)...Found areas too large to be of help."

"Can't distinguish between 97, 98 and 82-83 symbols (*in El Niño graphic from forecast agency*)"

This and other related feedback will be summarized and directed to forecast and hydroclimate information agencies, in order to improve product usability.

6. DIALOGUE ON WATER AND CLIMATE (DWC)

In addition to providing input to efforts aimed at improving development and dissemination of regionally relevant climate information, the END InSight initiative provides a framework for developing transboundary information. In conjunction with a project funded by the Netherlands-based Dialogue on Water and Climate (DWC) and in collaboration with the UA Udall Center for

Studies in Public Policy and the National Autonomous University of Mexico (UNAM) in Mexico City, CLIMAS is exploring ways to provide climate and related hydrologic information useful for transboundary, watershed-scale management in the upper and middle San Pedro River basin.

The San Pedro River is valuable for this initiative because it is located on the periphery of climate and hydrologic forecasting activities in both countries. Since the official climate forecasts of both countries and much of the existing climatological and hydrological data end at the international boundary, this area tends to be underserved in terms of good climate information. The area represents one of significant water conflict, where preservation of streamflows supporting a rich riparian zone and an internationally recognized bird sanctuary competes with long-established human uses. The regional watershed supports mining activities in the city of Cananea, Sonora and military and urban activities in Arizona, as well as rural ranching and agricultural livelihoods on both sides of the border. Such concerns have led to the Upper San Pedro being designated an international HELP basin, which has in turn facilitated acquisition of funding to address local and transboundary problems.

At the local grassroots level, efforts to address the conflicting demands on the basin's limited water supplies are being undertaken by the Upper San Pedro Partnership in Arizona and ARASA in Sonora. These groups, though different in level of expertise and capacity to institute change in the short term, form a valuable nucleus for exploring ways to develop and disseminate climate and hydrologic information specifically relevant in the interdependent, transboundary context. Through workshops and administration of a semi-structured survey, as well as transboundary interdisciplinary collaboration to develop and harmonize information for this border region, we are exploring innovative ways to improve the availability and flow of climate and hydrologic information and thus add to the array of decision support tools available to decision makers and stakeholders.

7. PROGRESS AND FUTURE DIRECTIONS

As of this writing (October, 2002), END InSight and DWC projects are still in their beginning phases. Surveys for END InSight will be collected for nine more months. The CLIMAS END InSight staff plans to submit a quarterly update to stakeholders, and to use the three months worth of responses gathered thus far in order to address stakeholder concerns and to adjust the content of monthly information packets. A stakeholder workshop, to evaluate the year's worth of information and gather feedback on product usefulness and usability is planned for June, 2003. Insights from the END InSight project will be applied to materials provided to San Pedro River stakeholders in the DWC project.

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