SOUTHWEST: CLIMATE ASSESSMENT OF THE SOUTHWEST

http://www.ispe.arizona.edu/climas/

Demand Side Assessment

- Who are the major stakeholders for your RISA?
  - The major stakeholders for CLIMAS are air quality managers, water resource managers, fire managers, land-use managers, public health officials, small-scale agriculturalists (including ranchers), tourism and recreation concerns, county and municipal managers. (See list attached at end of document.)
- What processes are used to include stakeholders in the research planning process, the research implementation process, and the research reporting process?
  - The two major processes that CLIMAS uses to include stakeholders in research planning are dialogue development, and taking advantage of events and opportunities. In the former, we develop topical dialogues on subjects important to stakeholders. During the process we exchange information, learn each other's vocabulary, and through iterative interactions refine concerns and problems into researchable questions. An example of the former is our work with air-quality managers in the Southwest. We developed our air quality research agenda through initial contacts with federal or regional agency offices (EPA, Western Governors' Association) and state or county-level departments of environmental quality. We then conducted a stakeholder workshop together with one of our partners (Pima Association of Governments), in which we garnered advice on decision contexts, and useful research outputs. The workshop allowed us to identify early adopters and research collaborators, who advised us on site selection and data to use in model development. In the latter example of our processes, stakeholder contacts, developed during the course of the project, have invited CLIMAS PIs to serve as co-authors on white papers and other reports. These reports were driven by events, e.g. severe drought, requiring expert input.
  - During the early years of CLIMAS we tried instituting an advisory board, with a multisector focus, to assist in developing a research agenda. The advisory board process was not sufficiently productive at the time and was discontinued in favor of other sector and project-specific forms of interaction and feedback.
  - Today, we include stakeholders in the research implementation process through information sharing, and review and evaluation of products. For example, CLIMAS researchers participate in an ongoing multidisciplinary research forum on Valley fever, an important public health risk in the semi-arid United States. Medical researchers in the forum advise CLIMAS researchers on continued basic science research and refinements to a decision-support tool developed by CLIMAS; in addition these researchers exchange data and information with CLIMAS. We have included stakeholders in reporting CLIMAS research through workshop presentations and internal reviews of manuscripts.
- How are stakeholder interactions evaluated?
  - Evaluations of stakeholder interactions vary depending on the purpose of the evaluation. Evaluations may be done, for example, to determine allocation of project resources and potential need for leveraging from other sources, to prioritize research initiatives, to assess success in knowledge transfer and exchange, and to assess the utility, usability, and timeliness, of specific products or suites of products.
  - One criterion for evaluating success is receipt of repeat requests for interaction or information. In some cases, achieving sustained interaction is a metric for evaluation. In our work with the Governor's Drought Task Force, for example, interactions have led to enhanced credibility, continued engagement, and involvement in larger initiatives. In other cases, such as our experience in generating interest in paleoclimate information, stakeholders did not respond until years later, when an event (in this case, severe drought) generated interest.
- What has your RISA learned from the process of stakeholder interaction, and how have its decision processes changed as a result?

- The most valuable lesson we learned was that stakeholder interaction requires iterativity, which Lemos and Morehouse (2004) defined for integrated assessments as achieving three objectives: a good fit between knowledge production and application, disciplinary and personal flexibility, and availability of resources. Achieving iterativity requires ongoing collaboration, time, persistence, and identification of areas of mutual concern and interest.

- Developing multidirectional formal and informal communication channels, and developing ***trust*** between scientists and stakeholders are also fundamental to building sustainable stakeholder relationships. These goals are most effectively achieved by working at regional and sub-regional levels.

- Stakeholder interactions have affirmed the very high value of working in an area that has regional-scale ecological, climatic and social coherence; such coherence facilitates development of knowledge and products that cut across geographical locales and social structures. At the same time, demand exists for climate information that has salience at subregional levels, especially at the watershed scale. Stakeholders participating in our drought-related research expressed the need for watershed-scale drought analysis, forecast, and planning information. The watershed is a unifying theme for climate vulnerability assessment, because commonalities in livelihoods, water supplies, natural resources, and management concerns are linked at this scale. Based on this insight, we have tailored our rapid rural climate vulnerability assessments to the watershed scale. Moreover, in 2003-2004 we decided to invest resources and effort to an integrated multidisciplinary investigation of vulnerability to long-term climate variations and climate change in a single watershed.

- We have also found that tailoring information to fit stakeholder needs, for example to fit decision calendars, is very important (Bales, Liverman and Morehouse 2004). For example, working with fire managers we learned that key resource allocation decisions are made by March of each year. We also learned that fire seasons very geographically across the country. Therefore, we adapted our annual fire-climate workshop to meet stakeholder needs, by holding a separate winter workshop for the eastern and southern United States, and a spring workshop for the rest of the country. Working in conjunction with the Western Water Assessment RISA, we decided to put greater effort into climate education for fire managers and to emphasize particular climate products valued by those managers (e.g., 14-day and seasonal forecasts, and snowpack monitoring tools).

- Our END InSight project (Carter et al. submitted) demonstrated the importance of conducting longitudinal studies of use of climate information and of packaging specific products and thematic information pages, with interpretive guidance, on a regular basis.

- We learned how to better estimate the amount of time and effort involved in stakeholder-oriented projects and processes. Effective projects require evaluating trade-offs between project breadth and time. We decided to invest more heavily in a smaller number of projects that are sustained, lead to improved multidisciplinary integration and increased stakeholder contact. We now attempt to explicitly address stakeholders' short-term (often value-added repackaging of existing information) and long-term (novel research) needs. By balancing our work on multiple time horizons, we can gradually develop the resources necessary to meet stakeholder needs and maintain relationships, with less team burn out and more realistic stakeholder expectations.

- We learned how to better define research questions, in order to simultaneously meet stakeholder needs for usable information and academic needs to perform challenging and publishable research.

- Our decision processes now include a greater role for partnerships. We realize that information is often best served through intermediaries, such as cooperative extension. These intermediaries typically serve as boundary organizations between our activities in collaborative production of applications-based science – which can include stakeholders – and diffusion of that scientific knowledge to users. In this process, we realize that it is of paramount importance to identify early adopters and key informants, as these people are likely to multiply the effectiveness of our efforts. Moreover, we realize that we cannot do everything for all stakeholders with our

limited resources. Partnering expands our capabilities, enhances our credibility and promotes greater acceptance of research results, as well as decision support processes and products.

- How did you develop your process for eliciting stakeholder needs/wants?
  - Stakeholder needs/wants are elicited through a combination of supply and demand or push and pull. In some cases we "push" information and research that we suspect stakeholders need. In other cases, things develop "organically," out of explicit or implicit stakeholder articulation of needs. An example of this latter case may be found in development of downscaled climate information in response to repeated comments from stakeholders that existing information was too coarse to be useful in their decision making processes. Specific efforts to identify stakeholder needs/wants include an initial stakeholder survey conducted at the inception of the CLIMAS project, participation in meetings such as those held by local cattle growers' association groups and by the Natural Resource Conservation Districts, organization of workshops for specific sectors such as water resource management, and organization of workshops involving a mix of stakeholder interests. One of the significant outcomes of these types of collaborations was a demand-driven pull for a formal forecast evaluation product that went beyond evaluation of individual forecasts.
  - We also elicit stakeholder needs and wants through rapid rural multi-sector assessments of vulnerability to climate variability and change. Our rapid rural assessments are based around watershed boundaries and common livelihood issues. Key to the effectiveness of rapid rural assessments are snowball sampling techniques, repeated intensive visits that include extensive ethnographic interviews, and integration between CLIMAS social and physical scientists.

Supply Side Assessment

- Briefly describe the research agenda for your RISA.
  - The CLIMAS phase 2 (2002-2007) research agenda is guided by the following overarching science questions:

    Climate and hydrological variability and forecasts
    - What is the nature, and what are the causes of climatic and hydrologic variability in the Southwest on interannual, decadal, and century time scales?
    - How do climatic and hydrologic variability vary geographically within the region?
    - How predictable is seasonal to inter-annual climate and hydrology, and how might better mechanistic understanding of climate affect predictability?

    Vulnerability and impacts
    - What are the impacts of climate variability on local populations and what sectors are particularly vulnerable?
    - How does climate variability affect Native Americans and their lands, and what sectors/populations are particularly at risk?
    - What are the impacts of climate variability on ecological processes and interactions, and on conservation/preservation efforts?
    - How do local populations adapt - short term and long term - to climate variability, and how do larger changes in the economy and in resource tenure influence their ability to cope?

    Use and value of climate information
    - What use is being made of climate information in the Southwest, what is the demand for and value of improved climate information, and how can climate information and uncertainty be best communicated to stakeholders?
    - How might a better understanding of climate benefit vulnerable stakeholders in the Southwest?
    - How can economic information and incentives analysis contribute to improving dissemination and use of climate and related information?

- What are the best methods for integrating information on climate, hydrology and vulnerability into assessments and decision support systems that respond to regional needs?

° Tasks include the following:

- assessment of vulnerability and adaptation to climate in representative southwestern rural communities and in northern Mexico;
- analyses focusing on the co-production of science in the water and fire sectors;
- economic analysis climate impacts on water and agriculture;
- investigation of climate and health interactions;
- research on climate-fire interactions, and annual fire-climate workshops;
- climate and hydrologic forecast evaluations;
- improvement of snowpack assessment for hydrologic forecasting (discontinued in summer 2005),
- refinement and expansion of fine-scale, gridded paleo and modern climate data;
- diagnostic studies focused on the nature and causes of climatic and hydrologic variability in the region;
- research on drought planning and drought management;
- development of CLIMAS information products, in conjunction with agency partners;
- structured assessment of stakeholders' interpretation and use of climate information, including stakeholders' needs for climate information.

- How does your RISA set its own research priorities?

° CLIMAS has relied on the overall objectives outlined in the NOAA-OGP RISA Program description to formulate our research agenda. We are committed to gaining a better understanding of climate and its impacts in the Southwest, and to providing insights and information regarding what sorts of climate services/products are needed by whom, when, and for what purposes.

° The initial research priorities were in part guided by a USGCRP climate change workshop held in Tucson in 1997. The need for better climate information to manage water resources, for example was a major theme stressed by participating stakeholders. Two other important decisions were also made as a result of this initial meeting; the first was to emphasize climate variability as a way of engaging a range of stakeholders who might have rejected efforts related to climate change, and the second was to draw on lessons from the Human Dimensions of Global Change community by explicitly emphasizing the integral nature of the social sciences in climate assessment.

° Research priorities are set, in part, in anticipation of or in response to events. For example, the decision to place a high priority on fire and drought research was a result of (a) anticipated needs for climate information on these topics -- based on the results of prior research, forecasts, and careful climate monitoring, and (b) needs expressed by agency partners and stakeholders.

° Research priorities are also determined based on available expertise and resources.

° The mechanics of setting the research agenda, include

- exchange of information and discussion of research and "climate events"during bi-weekly team meetings
- discussion and setting of preliminary research priorities by CLIMAS executive committee
- changes to research priorities are made by consensus of all CLIMAS PIs
- changes to overarching goals and guidelines are made during proposal processes

- How has this agenda evolved over the duration of the RISA? What new projects have been started that were not anticipated at the beginning of the RISA? What projects have been terminated, and why?

- Our fundamental research agenda of linking science and stakeholders, as outlined above, has remained relatively unchanged over the duration of CLIMAS. Naturally, there have been changes in the selection and mix of specific projects over time that reflect "adaptive management" in response to recognized opportunities. These fall into two categories:
  - Probably the largest evolution of our research agenda was the decision to be nimble in responding to opportunities. While these new projects fit clearly within our vision and mission, we did not anticipate their scope or topic in our formal proposal. This flexibility has been exceptionally valuable, resulting in several of our most successful projects. These projects grew rapidly out of initial contacts and exchanges, and required internal reallocation of priorities and funds within the confines of an annual budget cycle (see the next section on "New projects, not anticipated" for examples).
  - A second evolution was recognizing the variation in individual project life cycles. Some are finite in time, centered around a product or service, others have a high-activity phase (e.g., in association with a graduate student thesis, or a climate event) sometimes preceded and usually followed by a period of lower activity with sustained contact, and yet others are more-or-less permanent over time. This view is a strong departure from conventional research grant practice, and it also underscores the flexibility needed to optimize CLIMAS activity with stakeholder needs.
  - Both of these valuable developments in the character and execution of our research agenda have been enabled by an extended funding commitment from NOAA. This commitment has also enabled us to sustain critically important long-term iterative relationships with stakeholders.
- New projects, not anticipated:
  - Fire sector research. In particular, we did not anticipate collaborative work on fire outlooks and fire management decision-making processes.
  - Monthly climate outlooks. We did not anticipate the combination of El Niño and drought and other potentially confusing climate situations that might require a rapid response to stakeholder needs for information. Moreover, we never anticipated the ongoing need for quasi-operational climate information products, and the value that producing these products would provide to the project.
  - In 1997, when the project was conceived, we did not anticipate the relatively rapid development of extreme drought in the Southwest. Therefore, we did not anticipate our extensive foray into drought planning, drought policy, and supporting operational drought monitoring.
  - We did not anticipate that forecast evaluation would require long-term, sustained effort.
  - We added resource economists to the project, in response to stakeholder and agency needs for information on the economic impacts of climate variability.
  - The CLIMAS fine-scale climate mapping project, based on multi-sector stakeholder requests for improved data, evolved into the multi-institution WestMap initiative (now funded under NOAA-OGP's National Climate Transition Program).
  - We did not anticipate inter-RISA research projects and other efforts.
  - We did not anticipate the need for "Climate 101 for Society," and the requests for workshops and materials to build capacity for decision-making. These workshops have become somewhat of a cottage industry.
  - In 1997, we did not anticipate the emergence of West Nile virus as a major climate-related public health threat.
- Terminated projects.
  - We terminated spatial snow estimation project, due to the need for extensive additional resources. In addition, this project suffered from a, lack of stakeholder engagement during the long turnaround time necessary for the development of a decision-support product.
  - The paleoclimatology basic research effort was completed. An investigtor left the project, in order to pursue more

basic science research. The project continues through the analysis of the data produced during the first several years of the project.

- The Native American research project was terminated at the request of the Native American community. They preferred to be included as part of sectoral research, rather than be considered as a unique sector.
- CLIMAS ranching initiatives were terminated after investigators left the project. The first investigator left the project after completion of initial reports to providing background on ranching stakeholders. The second investigator, who researched rangeland economics, left the project after failing to attain tenure at the University of Arizona. CLIMAS continues to work with ranching stakeholders, albeit in a less structured manner.

- In your RISA, what is the balance between research on new subjects, and assessment/compilation of existing knowledge? How is this balance determined?
  - The balance between new research and assessment/compilation of existing knowledge is not readily quantifiable, but we estimate that fundamental research (i.e., research that seeks to produce new knowledge) accounts for about 40 percent of our effort, and assessment/compilation for about 60 percent.
  - Broadly speaking, the balance between new research and assessment/compilation of existing knowledge is negotiated through interactions within our Executive Committee and with the full complement of CLIMAS PIs. The Core Office provides a substantial balancing point through its responsibilities for building bridges between science and society, which involves disseminating existing information as well as participating in the development of products based on new research.
  - In some cases, work on new projects has been driven by the thesis interests of individual graduate students (e.g., the Valley Fever research effort).
  - In other cases, events (eg, the recent drought) have generated opportunities to mobilize, refine, and package existing knowledge to meet stakeholders' specific needs.
  - Also influential in balancing our research activities is viewing our activities as a progression over time, beginning with a "Climate 101" effort to educate stakeholders about what information exists, where/how it can be accessed, and what it says about climate, through vulnerability assessment to identification of needs that can be met through value-added compilation, evaluation, and repackaging of existing information and, where appropriate, new research to fill identified needs.
  - An additional, and very important, factor is keeping up with or staying ahead of current topical issues and events and sustaining sufficient flexibility to mobilize when conditions provide unanticipated opportunities for identifying and filling needs for climate information and climate research.
  - An example of balancing new research with compilation is the CLIMAS paleoclimate effort. We did not develop any new tree-ring *chronologies* (which requires field work); however, we developed new tree-ring *reconstructions* (which requires analysis and re-combination of existing data) using improved methodology. The stakeholder interest was long, climate division-level paleoclimate information; the scientific interest was comparison and evaluation of methods used to create the reconstructions.
- Please describe the specific ways that knowledge is disseminated from your RISA. How would you assess the relative importance of various dissemination mechanisms, such as peer-reviewed publications, other types of publications, web-based presentations, public fora, etc.?
  - CLIMAS disseminates knowledge through the following mechanisms: peer-reviewed publications, white papers and conference proceedings, trade journal articles, quarterly newsletters, factsheets and brochures, occasional web-based PDF reports, monthly web-based publications, web pages, interactive web tools, e-mail listservs, newspaper opinion pieces, public talks, stakeholder workshops, academic conferences/stakeholder conferences, climate-related training sessions, and press briefings.

- Text-based dissemination.
  - Peer-reviewed publications are most effective for conveying results to our scientific peers. Very few, more sophisticated, stakeholders are interested in peer-reviewed literature.
  - White papers are enthusiastically received by agency stakeholders, committees, and mid-level resource managers, as they provide substantial detail and can be made available in hard copy and on the web.
  - Newsletters, factsheets, brochures, are effective at reaching many managers, and for disseminating interim results at workshops and conferences. Some managers have commented that they are more likely to read items 1-4 pages in length than they are to read longer items. We make many of these items available on the web, as well.
  - Our monthly climate summary is disseminated by e-mail notice accompanied by an executive summary and a link to PDF and HTML versions. Stakeholders have remarked that 2-4 page articles that accompany the monthly summaries are exceedingly valuable, because they provide a combination of climate fundamentals, new insights, and evaluation of recent events, all of which are written in a journalistic style. Stakeholders remarked that they were not aware of similar easily-accessible materials on regional climate topics. Our investigations indicate that stakeholders value regular, monthly climate-related content presented in a consistent format.
  - We have only recently delved into trade journal publications, so it is too early to evaluate their effectiveness. However, water resources managers indicated that they would be more likely to read research reviews in professional society journals and newsletters than in even the most widely distributed science journals (e.g., BAMS, EOS).
  - We have not evaluated that efficacy of distributing information through HTML web pages. Our informal observations show that this is an effective medium for some stakeholders, and that it is effective for archiving data and reports of interest to stakeholders.
  - Interactive web tools are important for disseminating some information, such as forecast evaluations. Web tools are most effective when accompanied by training.
- Oral dissemination.
  - Stakeholder workshops are exceedingly effective for conveying research results, synthesizing the state of knowledge and raising awareness about an issue, and in generating further interest in climate-related issues and possible collaborations. The effectiveness of workshops is enhanced when accompanied by written materials (in print and on the web). Workshop face-to-face interactions cement relationships, enhance credibility, and instill trust. These workshops have, by and large, been worth their weight in gold.
  - Stakeholder professional society conferences are important venues for raising awareness about issues and developing future collaborations. Recently, we have focused more effort on providing professional development workshops and trainings at professional society conferences. The credibility of information presented at these conferences and trainings benefit from the imprimatur of the professional society and by connection to the overall mission of the professional society. In our view, working with professional societies is one of the more effective ways of conveying information.
  - We have found that it is exceedingly effective to disseminate information through intermediaries, such as cooperative extension agents and specialists.
  - Academic society conferences are valuable for alerting peers to research projects and results, and for developing collaborations. Occasionally, our work gains a multiplier effect from media reports about these conferences.
  - Press briefings are valuable, especially when the information presented is connected with topics of broad interest and timely subjects (e.g., "Is the drought over?" "Will this be a devastating fire season?"). We have used press briefings effectively to counteract previously sensationalistic coverage (e.g., associated with

topics such as El Niño). Regular briefings are less effective, as journalists require a salient "hook." We have also held press briefings associated with stakeholder workshops. These are most effective when connected to pre-meeting press releases. Perhaps the most valuable aspect of our interactions with the media has been to foster working relationships and to gain credibility and reliability as a source of information.

- Summary. The most effective means of disseminating information from CLIMAS include stakeholder workshops and trainings, hard copy newsletters and factsheets, and regular monthly publications distributed through the web. White papers and executive research summaries are effective for working with agency stakeholders. We believe that presenting information at stakeholder professional society meetings, as well as through their journals and newsletters, is potentially an exceedingly effective means of information dissemination. Similarly, boundary organizations, such as cooperative extension, are effective at multiplying our efforts to disseminate information. Press briefings can be valuable, but are less reliable.

Reconciliation/Managing Ecology of S&D

- In what ways have considerations of supply for research shaped the evolution of your research agenda?
  - Research supply has shaped the evolution of the CLIMAS research agenda chiefly through the expertise of individual investigators and their students. For example, CLIMAS has devoted substantial resources to hydrological investigations and ethnographic analyses, due to the renowned expertise of individual investigators. Conversely, a lack of expertise (supply) in visualization and state-of-the-art web-based knowledge transfer, combined with limited financial resources, has thwarted a planned effort to emphasize research activities and products concerning the communication of climate information, especially with respect to graphics, visualization and cartography. Instead, given financial constraints, we chose to emphasize better science writing in our outreach products, and to leverage decision-support projects with other closely-related projects on campus (e.g., the EPA-funded WALTER project for wildfire decision support [http://walter.arizona.edu]).
- What tensions have arisen between stakeholder needs, demands, and expectations, and the scientific capabilities and priorities of the RISA? How have those tensions been addressed or resolved?
  - Tensions have largely involved three general topical areas: the spatial scale at which climate information is provided, assessments of the accuracy and skill of climate forecasts, and lack of good monsoon forecasts (onset, intensity, intraseason dry spells, end).
  - With regard to monsoon research, for example, CLIMAS stakeholders have been almost unanimous in calling for improved forecasting and better information on spatial variability of monsoon precipitation. Delivering the needed information is beyond the scope and capability of CLIMAS resources. We address this tension by providing annual monsoon summaries, and by reporting on NAME science activities in our monthly climate summary. In addition, we devote some effort to applied monsoon research, primarily for the fire management community.
  - Similar issues exist with regard to providing information at fine spatial scale. For example ranchers wanted information specific to individual ranches, which CLIMAS is not in a position to provide. This tension was resolved via education on the nature of climate data and its availability, provision of interim gridded data, and most recently by obtaining separate funding for a specific project to provide such data (WestMap).
  - We identified some tension between needs and capabilities involving stakeholder need for frost forecasts. CLIMAS did not have the capability to produce frost forecasts and, due to NWS policy, it is not seen as an agency responsibility. The primary issue is that responsibility for producing frost forecasts was transferred to the private sector, but the forecasts that have been produced since the transfer have not been useful to stakeholder groups with whom we have established communications.
  - There is a definite tension with regard to our ability to turn around research within the time frame most desired by stakeholders. Often stakeholders require a research results in less than one year, and frequently they require results "yesterday." We have addressed this tension in several ways, including (a) identifying value-added

information that we can provide in a short time span, while keeping the stakeholder group engaged in the long-term effort, (b) by shifting effort to stakeholder implementation efforts. An example of the latter is our work with the Governor's Drought Task Force. We were only able to provide part of the research and information necessary during the development of the state drought plan. Following the successful development of a state drought plan, we shifted our efforts to providing support for emerging issues and drought plan implementation. Our plan implementation work includes evaluating impediments to drought plan implementation in rural communities, developing a drought impacts database, and holding workshops to develop drought planning and monitoring capacity in rural areas.

- Another tension is the mismatch between stakeholder's interpretation of available information and (a) the extensive information actually available, as well as (b) content that can be gleaned from correctly interpreted available information. We have addressed this tension through workshops and trainings.

- How does your RISA evaluate the appropriateness of stakeholder needs (e.g., from the standpoint of public/private sector roles and responsibilities)?
  - The major climate-related issues in the Southwest are drought, water resources, and fire. In each of these three areas, there is no closely relevant private sector attention focused on providing climate services of the type carried out by CLIMAS. Private sector roles and responsibilities are evaluated in preliminary discussions on new research projects. Continued stakeholder engagement also enables us to monitor changing circumstances in this regard, should such a sensitive situation emerge.
  - CLIMAS (via our core office, project personnel, or via P.I. meeting) assesses the appropriateness of stakeholder needs on a case-by-case basis as information or service requests are received. It is seldom an issue because we have defined ourselves as less product-oriented and more engagement-oriented. Therefore, we sometimes refer product-oriented stakeholders to other entities. We are also concerned about equity, again discussing this issue on a case-by-case basis. For example, with the forecast evaluation tool project (Hartmann et al., 2002) it was important to the investigator to maintain open source code rather than develop proprietary software. The CLIMAS Team has a strong commitment to equity, thus we do not do consulting work.
  - Frost forecasting has been a private sector activity for a decade. We recognized this in early interactions with stakeholders and the NWS, and have therefore not become involved.

- How are stakeholders identified? Which stakeholder groups are most important in influencing your RISA research agenda? Why? Which stakeholder groups are least important? Why?
  - Stakeholders are identified through strategies such as conducting surveys, holding workshops, attending public and professional meetings, and monitoring news coverage of climate-related stories.
  - Determining which stakeholder groups are most important to our research agenda involves strategies such as assessment of a group's openness to learning about/using climate information, availability of intellectual resources and interest among researchers to pursue particular avenues, and availability of resources to actually conduct the needed research.
  - For example, CLIMAS made an explicit decision *not* to target large agricultural stakeholders in our region, in part due to lack of interest among CLIMAS PIs in pursuing the subject and in larger part because much of the "big agriculture" in Arizona traditionally expressed little to no interest in climate. In fact, some agriculturalists have flatly stated they would prefer if it never rained, because precipitation merely interrupts their irrigation schedule. These stakeholders are well insulated from the vicissitudes of climate by availability of Colorado River water, to which they have the highest priority rights. Further, there was not much value added work that we could do. There was no obvious "low-hanging fruit" and only marginal benefit would accrue either to the farmers or to the researchers from the amount of effort required to do the extensive research that would be needed.
  - Instead, our agriculture-related research has emphasized study of rural livelihood vulnerabilities, using well-

developed rapid rural assessment methods.. We have placed a high priority on equity in these vulnerability assessments and subsequent efforts to deliver needed climate information.

- Importance *per se* is not necessarily the only criterion for selecting projects within CLIMAS. For example, we recognize that one of the very important areas of concern in the Southwest is the impact of climate on ecosystems. However, until recently the project lacked substantive connections with stakeholders in the wildlife/land management/ecosystem management sectors. Further, even having recently established a stakeholder base, lack of resources prevents us from initiating extensive research activities in this area. Addressing the myriad ecological issues would require bringing in additional university-based investigators, agency scientists, and entities representing NGOs and the public work through other University of Arizona or multi-university large science efforts.
- Another criterion for identifying stakeholder groups is the status of our resources for extensive travel to areas distant from our home base at University of Arizona. Due in no small part to limited resources, much of our work has been conducted in Arizona. In the process of working within a relatively easily accessible radius of campus, we have been able to establish a team-building process that has in turn provided a firm foundation for developing and refining our collaborative process. This process has allowed us to focus on developing a successful integrated assessment and climate services model.

- How does your RISA evaluate its research planning process?
  - Renewal proposals. In the process of writing our 2002-2007 renewal proposal, the PIs looked back over the first three-year funded period, seeking to discover the extent to which we had been able to deliver on the objectives articulated in the original proposal, the history of how we came to work on particular initiatives, the types of information and products that we were providing (or in the process of developing) to stakeholders, our internal success in achieving integration as an interdisciplinary team, and our progress in integrating stakeholders into our research process. We identified areas for improvement, such as the need to focus on integrating stakeholders more fully, and developed a set of research questions that would provide clearer guidance for activities to be pursued over the next five-year grant period. In recognition that introducing climate information into decision processes often requires some sort of change in conditions that renders "business as usual" untenable, we agreed to increase the team's flexibility to respond to unforeseen issues and event-driven opportunities (e.g., climatic conditions that generate big fire seasons, extended severe drought, etc.).
  - We established a four-member executive committee, made up of the lead PI and three co-investigators, to review research planning. The decisions and recommendations of the executive committee are presented to the full team of co-investigators for review, modification, and approval.
  - We initially established an advisory board to assist with planning and decision making; however, we decided to eliminate the board due to inability to effectively integrate board members into the project's activities, and due to the fact that the interests of board members were too diffuse to achieve a common vision. We now believe that we have sufficient experience and understanding in integrated, iterative research to convene an effective advisory board; this will likely occur as we move into our next funding phase.
  - More generally with regard to evaluation of planning efforts, we have consistently invested considerable time and effort in team building. We meet as a team every two weeks. The 10 principal investigators meet at least twice a semester, and the Executive committee meets at least that often. We conduct half-day team retreats each semester; at least half of the retreat time is devoted to evaluation of research and research integration. Moreover we occasionally hold weekend-long principal investigator and postdoc retreats. One of these retreats produced four papers summarizing CLIMAS experience with establishing climate services, developing stakeholder-driven science projects, and improving integrated assessment. All of the retreats and principal investigator meetings emphasize self critique.
- What lessons in the process of the reconciliation of supply of and demand for science are relevant to the broader

implementation of the CCSP?

- CLIMAS lessons in the process of reconciliation of supply and demand for science that are relevant to the broader implementation of the CCSP fall into the following categories: multi-party communication, sustained and iterative stakeholder engagements, adaptive/evolutionary approaches, regional foci, interdisciplinarity, collaborative efforts, resources and commitment.
- The CCSP, like the RISAs, will need to communicate with a variety of publics. Establishing and maintaining two-way communication among agency partners, between project members/administrators, and with stakeholders is essential to the success of CCSP. The foundation of successful climate services is relationship, and relationship requires commitment to solid, frequent two-way communication (i.e., avoiding the "loading dock").
- The CLIMAS experience demonstrates the need for commitment to long-term engagement and sustained iteration with stakeholders. Honing the stakeholder-scientist research process requires iterating many times with stakeholders. Stakeholders prefer face-to-face interactions. We've learned that stakeholders are more apt to use decision-support products, information, websites, if the products are accompanied by training and outreach. As one stakeholder noted, "don't put the burden on the user." CLIMAS has also learned that one-time engagements are far less successful than sustained and iterative engagements. One-time engagements often merely scratch the surface with regard to issues of mutual interest; moreover, needs and comprehension change over time – necessitating repeat engagement. Thus, demand comes with needs that must be met in order to increase the chances of success.
- Implementation of the CCSP stands a greater chance of success with the explicit acknowledgement that climate services is a process involving experimentation, evolution, and change. Examples of change that require a flexible process include:
  - Changes in science, technological improvements, and improvement in scientific understanding, changing paradigms, etc.;
  - The mutual understanding between stakeholders and scientists changes and develops in response to improved knowledge about (i) climate and products by stakeholders and (ii) specific stakeholder information needs by scientists. As stakeholder-scientist relationships evolve, they sometimes develop into partner-scientist relationships – whereby it becomes difficult to distinguish, e.g., agency stakeholders from partners in the research and knowledge-transfer enterprise.
  - External factors, such as climate and weather events, influence stakeholder needs and garner the attention of scientists;
  - Economic and social changes can result in changes in demand, as well as the ability to supply science.
  - In this regard, in some ways an end-to-end approach is misleading, as it implies the static completion to what we have observed as an ongoing process of anticipating, responding to, and meeting changing decision-making needs and scientific challenges. While the underlying philosophy is similar, instead of the "linear" imagery of the "end-to-end" approach, we prefer the "circular" imagery of what we term the iterative approach.
- CLIMAS believes that CCSP implementation will be enhanced by focusing on regional, subregional and local needs. The maxim states that "all decisions are local." Consequently, regional context and knowledge of key decision-making issues is important, including intimacy with regional atmospheric and societal processes.
- Commitment to and support for interdisciplinary work will enhance the chances for success. CLIMAS has found that interdisciplinarity among the natural and social sciences encourages novel approaches, synergies, and enhances the project's ability to bridge with stakeholders.
- We believe that collaboration between agencies and initiatives will improve CCSP implementation. Collaborations encourage the development of more effective synergies, and help to break down those barriers

to innovation that are due to institutional culture. Similarly, the efforts of constituent components of CCSP will be enhanced by creative leveraging of resources, which can be accomplished through inter-agency, inter-regional, and inter-disciplinary partnerships and collaboration.

- Successful use-inspired and user-oriented climate services, as part of the climate change science program, is a labor-intensive effort. The chances of successful implementation of the CCSP will increase in proportion to commitment of resources to human resources, in addition to obvious commitments to instrumentation, observations, modeling, and product development. In addition, having sufficient resources (funds, researchers, equipment, access to data) is essential.

Selected NOAA Partners

- National Weather Service Forecast Offices: Albuquerque, Phoenix, Tucson – drought, forecast evaluation, climate forecasts, press briefings
- NOAA-NWS Colorado Basin River Forecast Center – forecast evaluation
- NOAA Climate Services Division – forecast evaluation, knowledge transfer, climate forecasts
- NOAA Climate Prediction Center – forecast evaluation, fire outlooks, knowledge transfer
- NOAA Climate Diagnostics Center – drought, forecast evaluation, fire outlooks, climate data
- NOAA Regional Climate Centers: Northeast, Southern, Western – forecast evaluation, fire outlooks
- NOAA Office of Climate, Water, and Weather Services – forecast evaluation
- RISAs: Western Water Assessment, California Applications Program – drought, forecast evaluation, fire outlooks, fire decision making, climate data

- **Selected Agency Partners**
  - Arizona Cooperative Extension – forecast evaluation, drought, climate change, vulnerability assessment
  - Arizona Department of Health Services – health
  - Arizona Department of Water Resources – drought, vulnerability assessment
  - Colegio de Sonora – drought, vulnerability assessment, U.S.-Mexico studies
  - NASA-RESAC – snow estimation
  - National Drought Mitigation Center – drought, knowledge transfer
  - National Interagency Coordination Center (a division of the National Interagency Fire Center) – fire outlooks, forecast evaluation, fire decision making
  - Oregon State University – climate data
  - Pima Association of Governments – air quality, drought
  - Program for Climate, Ecosystem, and Fire Applications (a division of the Desert Research Institute) –fire outlooks, fire decision making
  - Scripps Institution of Oceanography – fire outlooks, climate data
  - USDA-Natural Resources Conservation Service – drought, snow estimation, forecast evaluation
  - United States Bureau of Reclamation – drought, water economics, forecast evaluation
  - United States Environmental Protection Agency – air quality
  - University of New Mexico – knowledge transfer, forecast evaluation
  - Upper San Pedro Partnership – vulnerability assessment, U.S.-Mexico studies
  - Western Governors' Association – air quality

- **Selected Stakeholders**

- American Meteorological Society – forecast evaluation
- Arizona Daily Star – knowledge transfer
- Arizona State Parks – tourism economics, knowledge transfer
- City of Chandler, Arizona – forecast evaluation
- City of Santa Fe, New Mexico – water economics
- City of Sierra Vista, Arizona – U.S.-Mexico studies
- Comision Nacional del Agua, Mexico – U.S.-Mexico studies
- Havasupai Tribe – agricultural economics
- National Predictive Services Group Geographic Area Fire Meteorologists and Intelligence – fire outlooks, forecast evaluation
- Navajo Nation – agricultural economics
- New Mexico Air Quality Bureau – air quality
- New Mexico Cooperative Extension – knowledge transfer
- New Mexico Department of Agriculture – knowledge transfer
- New Mexico Rural Water Association – knowledge transfer
- Pojoaque Pueblo – water resource economics
- Salt River Project – forecast evaluation, drought, use of ENSO information
- San Carlos Apache Tribe – forecast evaluation, vulnerability assessment, agricultural economics
- The Albuquerque Journal – knowledge transfer
- USDA-Forest Service – forecast evaluation, fire outlooks, fire decision making
- U.S. National Park Service – air quality, knowledge transfer, tourism economics
- Valley Fever Center for Excellence – health

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