CLIMATE SCIENCE POLICY: LESSONS FROM THE RISAS
WORKSHOP REPORT
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I. Executive Summary

On August 15-17, 2005, 40 scholars convened at the East-West Center in Honolulu, Hawaii to participate in a workshop titled "Climate Science Policy: Lessons from the RISAs". The primary justification for climate research in the United States is to provide 'useful' information for decision making. The genesis of this workshop, therefore, stems from the desire to explore one overarching question:

Are US climate research efforts resulting in the production of useful, and thus policy-relevant, scientific information for decision makers? In other words, are we making the right decisions about what science to conduct, and thus what scientific information to supply to decision makers?

This workshop focused on the lessons learned from the NOAA Regional Integrated Sciences and Assessment (RISA) programs based on the fact that these programs are widely hailed as a promising means to connect decision-making needs with the research prioritization process.

In conducting this workshop and related research, we utilize a framework that we call "reconciling the supply of and demand for science" (Sarewitz and Pielke, in press). In so doing we borrow concepts from the field of economics that recognize that there is both a supply side and demand side in the marketplace, and that both sides are effectively linked, modulated, and optimized through robust communication and a variety of other mechanisms. The same can be said for climate science policy in that decisions are made regarding what scientific information to produce, or supply, while users of scientific information simultaneously have specific information needs, or demands, that inform their decisions. In an ideal situation, scientific information that is produced is both needed and used by decision makers and research efforts that result in unused information are avoided or minimized. In simple terms, for science to support decision-making, the ideal situation is one in which the supply of climate science is reconciled with the users' demands.

Research to date indicates that the 'demand side' of climate science is better understood and characterized from individual to institutional levels than the 'supply side', which eludes characterization – to date – due in part to the dispersed nature of climate research and sheer scale of endeavor. In order to understand and evaluate how climate science research priorities and production on a national scale match up with the users' information needs, one should map both the supply and demand sides of climate information. Additionally, one should also explore how these two sides are reconciled through mediating processes and institutions. Given the scope of our research project, however, we chose to examine the RISA programs, drawing lessons from their experience that may be applied to climate science policy. Of particular interest is the desire to improve research prioritization, thus expanding options afforded to climate science policy-makers in order to improve the production of policy-relevant climate information for decision makers.

During the first day of the workshop, participants discussed and characterized the demand side of climate information in their particular contexts. Generalizing demands for climate information is difficult because users of information are context dependent; for example, each RISA focuses on unique policy problems in different regions of the country. Stakeholders are identified through a variety of mechanisms, including word of mouth, through existing relationships and through targeted outreach efforts. While some RISAs elicited users' information demands through informal interactions, others employed the expertise of social scientists to conduct directed studies or other formal needs assessments. While formal evaluation of stakeholder interactions have been minimal, most RISAs cite the importance of developing social capital in the form of trusting, long-term relationships with stakeholders in order to increase the likelihood of successful co-production of climate information.

On the second day, participants discussed and characterized their experience with the supply side of climate information. The issue of context emerged as one of the most important lessons in that researchers must tailor their information not only to the physical characteristics of the different regions, but to likely events, logistical realities, and users' understanding of the issues. RISA research activities were dynamic, and often changed or adjusted based on interactions with stakeholders and improved understanding of their needs. Mechanisms for prioritizing research priorities within RISAs also varied considerably. Disseminating climate information varied widely both between the RISAs and within each RISA, in that the RISAs would often utilize a variety of methods ranging from peer reviewed publications and reports to public presentations and web-based materials. Face to face interactions with stakeholders were often cited as a more effective means of disseminating information.

The third day of the workshop focused on the issue of reconciling supply and demand. One barrier oft noted by RISAs was the problem concerning the inherent limitations of climate prediction, in that stakeholders often requested such information that was usually beyond the capabilities of the RISA researchers. Mitigating tensions between the expectations of stakeholders and the capabilities of the RISA researchers was a necessary activity with many RISAs, and most found that educating stakeholders about the capabilities and limitations of science ameliorated such tensions. Again, few RISAs formally evaluate their research and planning processes, although every RISA identified at least some informal mechanisms by which to ascertain their success.

The workshop provided many valuable lessons about reconciling supply and demand of scientific information:

- Early, iterative, sustained and two-way communication is essential for reconciling supply and demand of scientific information.
- Good relationships, that is, ones based on trust, reciprocity and respect - both intra-RISA and with stakeholders - is necessary to build healthy and collaborative dynamics. Producing good and useful information is about understanding the full scope of the problem and thus context. To identify such characteristics, RISAS must actively engage stakeholders, thus good communication and healthy relationships are necessary.
- Effective process must also be dynamic, resilient, and adaptive to challenges, events and opportunities.
- Producing useful information inevitably involves trade-offs and attempts to balance various tensions, for example, the production of knowledge vs. provision of services; public vs. private interests; public-oriented vs. peer-reviewed products; breadth of research vs. depth; demands of parent program vs. needs of stakeholder community, etc.
- RISAs utilize a variety of approaches to engage with stakeholders, suggesting that there is no single 'best approach' for this kind of work.

- Despite the compelling evidence of RISA program success in producing policy-relevant information, these experiences have had little impact on climate science policy, yet there appears to be no easy answer as how to do so.
- An important next step for the RISA program is to become institutionalized within the broader climate science community.

Our findings from the workshop indicate that there are four primary approaches to reconciling the supply of and demand for climate information within the RISA programs.

- RISAs that employ a *'stakeholder-driven research'* approach focus on performing research in both the supply side and demand side as a contribution to reconciliation. Such efforts require robust communication in which each side informs the other with regard to decisions, needs, and products. The focus here is on decisions made by stakeholders.
- RISAs that employ the *'information broker'* approach produce little or no new scientific information themselves, due either to resource limitations, or lack of critical mass in a particular area. In this approach, the RISA sees their primary role as providing a conduit for information and facilitating the development of information networks. The focus here is on integration and sharing information deemed to be relevant to the information needs of decision makers.
- RISAs utilizing a *'participant/advocacy'* approach focus on a particular problem or issue, and engage directly in solving that problem. In this sense, they see themselves as part of a learning system and promote their research to a well-defined set of stakeholders who share the RISA's conceptualization of the problem and desired outcomes.
- Sometimes RISAs must utilize a *'basic research'* approach in which the researchers recognize particular gaps in fundamental knowledge that is necessary as a prerequisite to the production of context sensitive, policy-relevant information. Researchers, therefore, often establish some basic research as a priority within the organization.

In practice, however, each RISA often utilized many or most of these approaches at different times depending upon the particular context of the problem, showing reflexivity and adaptation in organizational practice and process. One factor that appears to influence a RISA's approach is also that of organizational longevity, in that the more well-established RISAs had more formal processes and procedures in place, having had more time to map their own field and problem area.

Finally, the workshop produced several lessons for climate science policy. The RISAs have learned a tremendous amount about what is needed to produce, package, and disseminate useful climate information, and have published many of their findings. Yet lessons from the RISAs appear to have had little influence on the climate science policy community outside of the RISAs, namely, those program managers and policy makers who could otherwise support the important function that RISAs play in reconciling supply and demand. Improving feedback between RISA programs and the larger research enterprise need to be enhanced so that lessons learned can inform broader climate science policy decisions.

RISA Acronyms:

CAP: California Applications Program

CISA: Carolinas Integrated Science & Assessments

CIG: Climate Impacts Group (Pacific Northwest)

CLIMAS: Climate Assessment of the Southwest

NEISA: New England Integrated Science and Assessment

Pacific RISA: (Hawaiian and US affiliated islands)

SECC: Southeast Climate Consortium

WWA: Western Water Assessment (Interior West)

II. Purpose of the Workshop

A. Introduction

In April 2002, the House Science Committee held a hearing to explore the connections of climate science and the needs of decision makers. The hearing charter included the following question[1]: "Are our climate research efforts focused on the right questions?" By "right questions" the Committee clearly meant questions whose answers are likely to lead to useful information to decision makers. The Science Committee's hearing highlighted the role of the NOAA Regional Integrated Sciences and Assessments (RISA) as a promising means to connect decision-making needs with the research prioritization process:

> One approach to producing policy-relevant information is the regional assessment model, developed within NOAA and other agencies, that attempts to build a regional-scale picture of the interaction between climate change and the local environment from the ground up. By funding research on climate and environmental science focused on a particular region, [the RISA] program currently supports interdisciplinary research on climate-sensitive issues in five selected regions around the country. Each region has its own distinct set of vulnerabilities to climate change, e.g., water supply, fisheries, agriculture, etc., and RISA's research is focused on questions specific to each region. The regional assessments are developed in consultation with local stakeholders such as resource managers, farmers, and emergency responders. RISA has been called a step in the right direction by some, although the program is small (approximately $4 million in FY 2003), while others view it as a model that could guide some of the larger efforts within USGCRP.

The RISA program is now 10 years old and has developed a significant body of experience in working to establish a two-way connection between decision makers and interdisciplinary science and assessment[2]. This experience provides a rich resource for drawing lessons from the various RISA projects on how science priorities might be set, research implemented, and the resulting output transferred to operational agencies in support of the needs of decision makers. The purpose of the workshop, therefore, was to focus specifically on how RISAs make decisions about prioritizing and conducting research given the goal of supporting decision making, in order to extract lessons from these experiences that might inform the larger climate science program enterprise.

B. What is the problem? Reconciling Supply of and Demand for Climate Science

Our research is motivated by a simple fact: there is both a supply side and a demand side for scientific information relevant to decision making. This suggests a hypothesis that is strongly supported by results from our prior research, as well as the work and experience of many others: the capacity of scientific research to support decision making is greatly enhanced when the supply side (i.e., researchers) and demand side (i.e., decision makers) understand each other's capabilities, needs, and limits.

We are consciously using the terms "supply" and "demand" because in the economic marketplace, supply and demand are effectively linked, modulated, and optimized through many mechanisms. If there is no demand for a product, companies will not produce it (or, at least, not for long)—or perhaps they will advertise aggressively to create a demand. Producers are constantly monitoring, assessing, and responding to consumer preferences so that they can enhance sales and profits. Competition between producers of similar products (e.g., different brands of CD players or pain killers), or dissimilar products that fill similar needs (e.g., CD vs. cassette players; aspirin vs. ultrasound) leads to constant evolution of both consumer preferences and producer outputs. In the high technology sector, a considerable

1. http://www.house.gov/science/hearings/full02/apr17/full_charter_041702.htm
2. http://www.climate.noaa.gov/cpo_pa/risa/

amount of incremental innovation comes in response to specific input from consumers. Overall, a key attribute of this coevolution of supply and demand is communication: producers are constantly striving to understand, influence, and respond to the preferences of consumers; consumers are constantly making choices among options in response to their own preferences, knowledge, and experiences.

Over the past several decades, scientific information has come increasingly to play a role in decision making at every scale from the individual (e.g., a person trying to understand if recycling provides an environmental benefit) and the very local (e.g., a mayor deciding whether to order an evacuation prior to a hurricane) to the global (e.g., governments negotiating climate change agreements). Here, there is a supply side and a demand side too, but formal or informal feedbacks to enhance mechanisms to ensure compatibility between the supply of scientific information and the demands of decision makers are often lacking. In the absence of such mechanisms, there are important factors at play, which militate against alignment of supply and demand, factors that reflect intrinsic differences between research and policymaking. For example, from the scientific (supply) perspective, the types of questions and problems that scientists are able to address or are interested in addressing are not necessarily those that decision makers need to have answered. And from the policy perspective, most important policy dilemmas are almost always underlain by value disputes that science cannot resolve.

Science policy scholar Harvey Brooks aptly characterized the inter-relationships of supply of and demand for scientific information:

> "If the process of using science for social purposes is thought of as one of optimally matching scientific opportunity with social need, then the total evaluation process must embody both aspects in an appropriate mix. Experts are generally best qualified to asses the opportunity for scientific progress, while broadly representative laymen in close consultation with experts may be best qualified to assess societal need. The optimal balance between opportunity and need can only be arrived at through a highly interactive, mutual education process involving both dimensions." (1996 p. 33)

Policy research increasingly documents that compatibility of scientific supply and decision-maker demand can be increased through mechanisms that enhance knowledge of, and communication between, the supply and demand sectors. When scientists and decision makers understand each other's capabilities, needs, and limits, research agendas can be better designed to support decision making, and decisions can be more successfully rooted to take advantage of scientifically robust information. Despite insights gained from several decades of scholarship in this area, however, the organization of climate science in the United States evolved with weak linkages between the supply of and demand for knowledge among the broad array of potential users and desired societal outcomes. Adopting Kitcher's term, we hypothesize that climate science is very far from being "well ordered", in which science addresses both the needs of free inquiry and is responsive to societal needs and values. More importantly, we suggest both that this hypothesis is testable and that, given the scale of public investment and the potential environmental and socioeconomic stakes, the effectiveness of science policies could be greatly enhanced from testing it.

As long ago as 1992, a first (and, as far as we can know, last) step along these lines was taken in the Joint Climate Project to Address Decision Maker's Uncertainty (Bernabo 1992). The project sought to determine "what research can do to assist U.S. decision makers over the coming years and decades," it argued that "[a]n ongoing process of systematic communication between the decision making and the research communities is essential," and it concluded that "[t]he process started in this project can serve as a foundation and model for the necessary continued efforts to bridge the gap between science and policy" (p. 86). Those continued efforts did not occur.

More than a decade later, the scale of the climate research enterprise has increased enormously, along with fundamental understanding of the climate system. At the same time we observe that there is little if any evidence that this growth of understanding can be connected to meaningful progress toward slowing the negative impacts of climate on society and the environment. On the other hand, appreciation of the variety of decision makers and complexity of decision contexts relevant to climate change has greatly deepened. Understanding of this diversity should allow us to ask: what types of knowledge might contribute to decision making that could improve the societal value of climate science? Next, we outline a methodology of science policy research for assessing and reconciling the supply and demand functions for climate science information.

a) **Demand Side Assessment**. Research on the human dimensions of climate, though modestly funded over the past decade or so, has made important strides in characterizing the diverse users of climate information, be they local fisherman and farmers or national political leaders; on the mechanisms for distributing climate information; and on the impacts of climate information on users and their institutions. This literature provides the necessary foundations for constructing a general classification of user types, capabilities, attributes, and information sources. This classification can then be tested and refined, using standard techniques such as case studies, facilitated workshops, surveys and focus groups. Given the breadth of potentially relevant stakeholders, such a demand side assessment would need to proceed by focusing on particular challenges or sectors, such as carbon cycle management, agriculture, ecosystems management, and hazard mitigation.

b) **Supply Side Assessment**. Perhaps surprisingly, the detailed characteristics of the supply side—the climate science community—are less well understood than those of the demand side. One reason for this of course is that over the past decade or so there has been some programmatic support for research on the users and uses of climate science, but no similar research on climate research itself. Potentially relevant climate science is conducted in diverse settings, including academic departments, autonomous research centers, government laboratories, and private sector laboratories, each of which is characterized by particular cultures, incentives, constraints, opportunities, and funding sources. Understanding the supply function demands a comprehensive picture of these types of institutions in terms that are analogous to knowledge of the demand side, looking at organizational, political, and cultural, as well as technical, capabilities. Such a picture should emerge from analysis of documents describing research activities of relevant organizations, from bibliometric and content analysis of research articles produced by these organizations, and from workshops, focus groups, and interviews. The result would be a taxonomy of suppliers, supply products, and research trajectories. As with the demand side assessment, the scale of the research enterprise suggests that this assessment process should build up a comprehensive picture by focusing sequentially on specific areas of research (such as carbon cycle science). This incremental approach also allows the assessment method to evolve and improve over time.

c) **Comparative Overlay**. Assessments of supply and demand sides of climate information can then form the basis of a straightforward evaluation of how climate science research opportunities and patterns of information production match up with demand side information needs, capabilities, and patterns of information use. In essence, the goal is to develop a classification, or "map," of the supply side and overlay it on a comparably scaled "map" of the demand side. A key issue in the analysis has to do with expectations and capabilities. Do climate decision makers have reasonable expectations of what the science can deliver, and can they use available or potentially available information? Are scientists generating information that is appropriate to the institutional and policy contexts in which decision makers are acting? Useful classifications of supply and demand functions will pay particular attention to such questions. The results of this exercise should be tested and refined via stakeholder workshops and focus groups.

		Demand: Can User Benefit from Research?	
		YES	NO
Supply: Is Relevant Information Produced?	NO	Research agendas may be inappropriate.	Research agendas and user needs poorly matched; users may be disenfranchised.
	YES	Empowered users taking advantage of well-deployed research capabilities.	Unsophisticated or marginalized users, institutional constraints, or other obstacles prevent information use.

The 2x2 matrix shown here schematically illustrates the process. We call this the "missed opportunity" matrix because the upper left and lower right quadrants reflect where opportunities to connect science and decision making have been missed. Areas of positive reinforcement indicate effective resource allocation where sophisticated users are benefiting from relevant science. Areas of negative interference may indicate both opportunities and inefficiencies. For example, if an assessment of demand reveals that certain classes of users could benefit from a type of information that is currently not available, then this is an opportunity—if provision of the information is scientifically, technologically, and institutionally feasible. Another possibility would be that decision makers are simply not making use of existing information that could lead to improved decisions, as Callahan et al. (1999) documented for regional hydrological forecasts. Finally, research might not be well matched to the capabilities and needs of prospective users, as Rayner et al. (2002) have shown.

d. **Institutional Context for Climate Science Policy**. As we have emphasized throughout this discussion, supply and demand must ultimately be reconciled via mediating processes and institutions—in this case, science policy institutions, such as relevant federal agencies, congressional committees, executive offices, non-governmental advisory groups, etc. Institutional attributes such as bureaucratic structure, budgeting, reporting requirements, and avenues of public input, combine with less tangible factors including the ideas and norms embedded within the institution, to drive decision making (e.g., Laird 2001, Schön and Rein 1994, Keohane et al. 1993, Wildavsky 1987, Kingdon 1984). How do managers justify their decisions? Are those justifications consistent with the decisions that they actually make? What ideas or values are perhaps implicit in the analyses and patterns of decisions that the institution exhibits? These sorts of questions can be addressed through analysis of internal and public documents, interviews, and public statements. We emphasize that it is the institutional analysis that provides the basis for identifying concrete alternatives for better reconciliation of supply and demand functions.

Our analysis of the evolution of the climate science enterprise in the U.S. indicates that policy assumptions and political dynamics have largely kept the supply function insulated from the demand function except in the area of international climate negotiations. Some modest experiments, notably the RISA (Regional Integrated Sciences and Assessment) program of the National Oceanographic and Atmospheric Administration, have sought to connect scientists and research agendas to particular user needs at the local level, but these lie outside the mainstream of the climate science enterprise.

A research effort of the type sketched here can illuminate how well climate science supply and demand are aligned, highlight current successes and failures in climate science policy, identify future opportunities for investment, and reveal institutional avenues for, and obstacles to, moving forward. The value of the method will in great part depend on how receptive science-policy makers are to learning from the results of such research. We are optimistic on this front for two reasons. First, the fundamental justification for the public investment in climate science is its value for decision making. This justification, repeated countless times in countless documents and public statements, is prima fascia evidence that climate science policy makers are committed to an enterprise that creates useful information. Second, and of equal importance, the very process of implementing the method we describe will begin to create communication, reflection, and learning among decision makers who govern the climate science enterprise, and various users and potential users of scientific information hitherto unconnected to the science policy arena. The result of this dynamic process will be an expansion of the decision options available to science policy makers, and thus an expansion of opportunities to make climate science more well-ordered. Undoubtedly, institutional innovation would need to be a part of this process as well, given the scale and scope of the climate science enterprise and the potential user community.

C. NOAA Regional Integrated Sciences and Assessment (RISA) Programs

We are focusing on the RISAs as a body of experience that offers the promise of learning about successes of and obstacles to reconciling the scientific supply of and demand for science. We are not interested in evaluating the RISAs with respect to their NOAA missions. We are happy to leave that to the RISA program managers. But we do think that the RISAs can teach us, the Climate Programs Office (CPO), National Oceanic and Atmospheric Administration (NOAA) and the Climate Change Science Program (CCSP) and beyond something about the challenges at the two-way interface of the complex relationship between decision making about science and decision making about climate. The RISA program explicitly seeks to work at the boundary of science and decision making.

> "RISA projects point the way toward a new paradigm of 'stakeholder- driven' climate sciences that directly address society's needs and concerns."
>
> "What makes science useful and usable for the public? Much work has gone into answering this question, and the RISAs have been at the forefront of the effort. RISA researchers place strong emphasis on working directly with people who have an investment—a "stake"—in activities, resources, or property that may be vulnerable to climatic impacts. These stakeholders hold the key to scientists' understanding of what kinds of climate information can aid the public in coping with climate variability, and how to provide this information in forms that people can actually use."[3]

A 2005 NRC Report that looked at experience in seasonal climate forecasting found this area to be rich for understanding connections of science and decision making,

> "…crucial to the success of such systems is that they incorporate user-driven definition and framing of the problem to be addressed. "User-driven" is used here to mean that the agendas of analysts, forecasters, scientists, and other researchers are at least to some degree set by the potential users of forecasts. The process of collaborative problem definition would be user driven, but reflect input from the scientific (producer) community on what is feasible."[4]

3. From the 2005 RISA Brochure.

4. Cash and Buizer, 2005, page 9

D. Workshop logistics and details

The 2005 "SPARC Reconciling Supply and Demand Workshop" was held August 15-17, 2006 at the East-West Center in Honolulu, Hawaii. The Workshop was divided into three days. Day #1 explored the characteristics of the demand side of the RISA programs. Each RISA team was allotted about ten minutes to give a prepared presentation, followed by questions from the audience. Day #2 explored supply-side characteristics utilizing the same approach. Day #3 explored how to manage the ecology between the supply and demand sides. For this session, each workshop participant was assigned to a particular group to answer the question: "What lessons have we learned from the RISAs for Climate Science Policy in the Climate Change Science Program?" The workshop participants then reconvened and each group presented its answers to the question.

III.Summary of Findings

A. Demand side assessment

The range of stakeholders is unique to each RISA program, yet most RISA stakeholders include local, county, regional, state, and federal officials. In the CAP, researchers also work at the international level collaborating with Mexican scientists, and several RISAs also work with various American Indian Tribes. Stakeholders also represent public, private, ngo and educational organizations. Since each RISA mission is unique, each set of stakeholders varies according to the particular climate problem area in which the RISA works. For example, CIG's mission includes four sectors of research and outreach including water resources; forests; aquatic ecosystems; and coasts and consequently its stakeholders include such groups as the Portland Water Bureau, Seattle City and Light, Washington Department of Fish and Wildlife and the International Halibut Commission among others. The NEISA program, on the other hand, has a comparatively narrow focus related to the study of climate, air quality and human health, thus its stakeholders come from sectors related primarily to those issue areas such as hospitals and state departments of health and human services. For many of the RISAs, agricultural, forest and water-related groups and agencies serve as primary stakeholders. Several other RISAs identify various offices and departments of emergency planning and services as stakeholders, as well as tourism-related interests (e.g. Pacific RISA). Still other RISAs count the media and general public among their stakeholders (e.g. WWA).

RISAs employ a variety of mechanisms for identifying stakeholders, for example, through existing networks related to the particular RISA research area, word of mouth, personal relationships and through recommendations through researchers extended communities. CAP notes the importance of boundaries, in that they seek stakeholders who manage porous institutional boundaries and avoid those with institutional walls (p. 49[5]). Several RISAs identify the need to seek out and work with early adopters who have good potential to engage in new tools and approaches to their decision making processes. The Pacific RISA also suggests that the nature of the science itself influences who potential stakeholders may be, in that "ENSO-based forecasts and climate change projections tended to focus on changes in rainfall, temperature so the user communities (stakeholder) most active in the early years were those for whom changes in those parameters were most directly relevant" (p. 59). Pacific RISA's emphasis on building resiliency to climate variability and promoting sustainability also shapes decisions regarding potential stakeholders.

RISAs use a variety of means for including stakeholders in the research and planning process. Many programs rely on interaction with stakeholders at workshops, conferences, professional meetings, and the like to meet with stakeholders and to identify their science information needs. Some RISAs also utilize briefings and publicizing of research as outreach

5. Citations from these sections unless otherwise indicated come from the "2005 SPARC Reconciling Supply and Demand Workshop: Climate Science Policy Lessons from the RISAs. August 15-17, East-West Center, Honolulu, Hawaii." CAP pgs 34-42; CISA pgs 43-45; NEISA pgs 46-50; Pacific RISA pgs 51-63; CIG pgs 64-70; SECC pgs 71-72; CLIMAS pgs 73-85; WWA pgs 86-91.

mechanisms in order to elicit stakeholder needs. A few RISAs, however, utilize more directed approaches to elicit stakeholder needs such as personal contacts with key individuals, interviews, directed studies, resource planning meetings and also consulting activities. In the case of the Pacific RISA, the process for eliciting stakeholder needs grew out of previous projects such as the Pacific Assessment and the PEAC review project. Findings from these efforts informed development of the Pacific RISA research and implementation activities confirming that "the concept that sustained communication and user engagement is critical o the co-evolution of climate science, information services and climate risk management policies" (p. 54). Between 1999 and 2001, the SECC conducted several Sondeos[6] comprised of scientists, agricultural extension agents and ranchers. Over the course of four Sondeos, the SECC identified several opportunities in which climate information could improve ranchers' decisions (Vedwan et al., 2005). The CLIMAS group describes two processes that contribute to stakeholder participation in research planning, that is, "dialogue development, and taking advantage of events and opportunities." They describe a process of information exchange as well as acculturation in which scientists and stakeholders "learn each other's vocabulary". Through an iterative process, both groups identify and refine specific research problems and questions. This iterative process continues through the research and reporting phase whereby stakeholders could be invited to collaborate on white papers or reports.

RISA programs identified several important strategies for eliciting stakeholder research needs and wants. The CISA, NEISA and CIG programs found that tapping into, and utilizing existing networks aided in outreach and helped foster relationships through which stakeholders could be identified and their needs elicited. The CISA program also engaged stakeholders who expressed early interest in long-term relationships. Other RISAs also identified developing relationships with stakeholders as important foundational steps prior to, and concurrent with, eliciting their needs. The WWA has found that personal relationships between researcher and stakeholder increases their ability to elicit stakeholder needs, and the Pacific RISA suggested that mutual respect is essential for healthy relationships. The CIG not only utilizes annual meetings to exchange information between researchers and stakeholders, but also takes advantage of these opportunities to "introduce the 'targeted' users of their research products to the specific CIG team members working in their area of interest" (p. 67). The CIG program works at developing and maintaining relationships with users, but these relationships avail the program of numerous opportunities for eliciting stakeholder needs, and indeed, for stakeholders to approach the CIG team members on their own initiative. The CIG suggests that producing useful information and products for users requires understanding the users' decision context, but cautions that "you can't rely on users to set the research agenda". CLIMAS seeks out 'early adaptors' and 'key informants' in order to leverage the multiplier effect, in that such stakeholders will disseminate information and products and thus broaden the CLIMAS audience. They also have a better understanding about research project selection recognizing the inherent tradeoffs between the size of the project and time constraints. The Pacific RISA also identified institutional and technical constraints as a conditioning factor in research and project design. The CLIMAS program utilizes a process that combines "supply and demand or push and pull" to elicit stakeholder information. At times, CLIMAS may "push information and research that we suspect stakeholders need. In other cases, things develop 'organically', out of explicit or implicit stakeholder articulation of needs" (p. 75). Unique among the RISAs is the CLIMAS approach to utilizing "rapid rural multi-sector assessments of vulnerability to climate variability and change…[utilizing] snowball sampling techniques, repeated intensive visits that include extensive ethnographic interviews, and interrogation between CLIMAS social and physical scientists" (p. 75).

Working with and engaging stakeholders has taught the RISA programs several important lessons necessary for effective production of useful information. Perhaps one of the most common exhortations by the RISA workshop participants

6. From Vedwan et al., 2005, p 5: "A *Sondeo* [italics in original] refers to a series of open-ended, interactive discussion among specialists from various disciplines and farmers or another target group (Hildebrand, 1981)."

was to develop relationships with stakeholders early and be prepared to develop the relationships over time, or as the NEISA program explains, develop engagement early and engage often. The CAP program concurs and includes the need to be responsive to the stakeholders and be attentive to effective outreach activities. The Pacific RISA explains that developing credibility and trust between scientists and users is "a long term endeavor", and CLIMAS explains that developing trust is "fundamental to building sustainable stakeholder relationships". The CLIMAS program suggests that "stakeholder interaction requires iterativity, which Lemos and Morehouse (2005) 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" (p. 74).

Another important lesson learned from stakeholder engagement is "to take advantage of windows of opportunities!" (p. 87), or, in other words, "be ready to strike" (p. 36). The CAP explains it this way: "Agencies, especially local agencies, are buffeted by many stresses each year and often place climate issues low among their priorities. When climate rises towards the top of their priorities, however they are eager for help, advice, and hard facts; during these intervals, much progress can be made in establishing connections and in developing long-term users of climate services" (p. 36). Several RISAs have adjusted their strategies of engagement or have adjusted the products they produce as a result of lessons learned. The Pacific RISA, on the other hand, has responded to the lessons learned from experience, recognizing that their users need continuous climate support as opposed to specific event-based products and consequently, the Pacific RISA has adjusted its priorities accordingly. Additionally, they understand that that forecasts and climate problems must be anchored to the specific context of the problem and of the long-term benefits of providing outreach and education. In providing information to stakeholders, the CAP makes sure to use clear and simple examples in order to convey their research. These examples offer compelling evidence of the importance for RISAs to respond to the particular context of their stakeholder's problems, underscoring the fact that there is no single 'best approach' to engaging with stakeholders.

B. Supply side assessment

The issue of context plays an important role in how RISAs set their research priorities. While users' expressed needs and desires definitely contribute to shaping research priorities, these needs constitute only a small part of the suite of characteristics that inform such priorities. For example, several RISAs explain that users' desired research must 'fit' with the research qualifications of the team of researchers. Other RISAs indicated the need for research to fit within the context of the larger research questions they explore as part of their organizational mission. For example, the CIG identifies how research opportunities fit with "knowledge relative to the regional climate system, linkages to sectoral impacts via environmental sensitivities, the level of understanding achieved within and across sectors" among others (p. 67). Other RISAs orient their research toward likely events (e.g. CLIMAS) and "the tractability of problems and issues" (e.g. CAP). Consideration of past research also influences research priorities. The Pacific RISA sets research priorities based on problems and needs identified through PEAC, and the NEISA program explored past research on asthma to inform research priorities. Mechanisms for deciding what research to prioritize varies considerably between RISAs, from less formal, ad hoc discussions among the RISA researchers, to more formalized procedures that link the organization's goals, mission and strategic plans to research selection. For example, the CIG utilizes an executive committee, comprised of PIs, to make such decisions.

Every RISA reports that at least some of their research priorities have evolved based both on feedback from stakeholders and on experienced gained from previous research, recognizing the need to deepen, broaden, or otherwise refine their existing research priorities. For example, both the CAP and CIG noted the need to change the scale of their research. NEISA expanded its notion of air quality to include "biological, chemical and physical properties of air" (p. 47). CLIMAS describes its approach to evolving research priorities as one based on "'adaptive management' in response to recognized opportunities" (p. 77; see also WWA). CLIMAS cites two examples of the need to respond to and leverage specific opportunities, such as the onset of drought in the southwest, and the research project 'life cycles'. In so doing, CLIMAS can "optimize [their] activity with stakeholder needs". CAP notes that some of its research is evolving in some areas from a more climate variability-oriented approaches to one that explores larger climate change issues. WWA reported significant "innovation and maturation" in its process of research prioritization, from one driven largely by researcher desires to one driven by stakeholder's needs and specific events that open opportunities for research (p. 89). Most RISAs have maintained their research programs, but lack of funding has lead to the termination of some, while lack of stakeholder interest led to the elimination of others. Balance between research on new subjects and compilation and dissemination of existing materials varies between RISAs.

Utilizing multiple methods and fora for disseminating information about their research and findings are common characteristics among RISAs. Examples include peer reviewed publications, reports and white papers, guest lectures, workshops, public presentations, brochures, PowerPoint presentations, reports written for public consumption, consultancies, email list-serves, trade journal articles, professional conferences, meetings with stakeholders and users, newsletters and web-based information exchanges such as each RISA's program web page. The Hawaii RISA emphasizes the importance of "eyeball - to - eyeball" interaction as a critical component to its process of information dissemination, particularly given some of the regional limitations associated with electronic transfer of information (p. 57). Several RISAs also use the media as a mechanism for dissemination such as issuing press releases, writing editorials and even writing the occasional article. While peer-review publications offer less value to stakeholders, RISAs note the importance of such publications in terms of establishing and maintaining professional credibility, not to mention the value that such publications contribute to tenure, retention and promotion considerations. Nevertheless, most RISAs note that some of the most effective mechanisms for information dissemination include direct contact with stakeholders, whether through workshops, meetings or face – to – face interactions. Additionally, many of the programs provide at least some introduction to climate science to their stakeholders, such as 'climate 101' (p. 78) type material and educational outreach programs (e.g. CISA, WWA, etc.).

C. Reconciliation/Managing the Ecology of Supply and Demand

Several factors shaped RISA research priorities. For some RISAs, the lack of fundamental knowledge about scaling down climate modeling, for example, compelled them to undertake additional research in more fundamental science, a necessary step prior to producing policy-relevant information. The Pacific RISA recognizes explicitly the role that both supply of scientific research and demand for information by stakeholders influences research priorities. In response to this view, the Pacific RISA actively engages both scientists and stakeholders as partners in the process of reconciling the supply of scientific information with user demands and then communicates these needs to the scientific research community with whom they collaborate (p. 58).

One of the most often cited sources of conflict between stakeholder needs and the scientific capabilities and priorities of the RISAs is that of climate prediction, in that stakeholders often request information about future climate variability in temporal, spatial or other scales that science just can't produce (e.g. CISA). CIG responded to such demands by refocusing stakeholder's attention and understanding from prediction to resilience (p. 69). Some 'tensions', RISAs note, cannot be resolved given funding limitations. The Pacific RISA notes that funding limitations may have precluded the rise of potential tensions, in that they have had to evolve primarily as an "information broker – facilitating the dissemination of scientific information developed by the broader scientific community and supporting the user interactions that will help guide future climate research …" (p. 58). CLIMAS resorts to educating users to diffuse some tensions, in that when stakeholder demands are unrealistic, CLIMAS explains the nature and limitations of research to stakeholders. They also note that stakeholders often demand information on very short time scales that CLIMAS finds difficult to meet. Consequently, they reduce potential tensions by "identifying value-added information that we can provide in a short time span, while keeping the stakeholder group engaged in the long-term effort" (p. 81). They also shift emphases from solely providing information to including information on implementation of potential options. CAP identified success in avoiding tensions by making explicit to their stakeholders the limitations of their research if user expectations "seemed too wildly optimistic" (p. 40). For their part, NEISA emphasizes their role as 'partners' in the process rather than 'experts' in order to dampen unrealistic stakeholder expectations (p. 48). NEISA also responded to user expectations by bringing in scientists with appropriate backgrounds to address stakeholder expectations.

Few RISAs have an explicit plan or approach to evaluating the appropriateness of stakeholder engagement from the standpoint of public/private sector roles and responsibilities. Yet many integrate such concerns into their organizational plan or mission. CIG developed a very clear guideline for engagement and, "refuse[s] to engage in proprietary work and require[s] openness of information/data produced in research" (p. 69). CLIMAS notes that in its major sectors of research (water, drought, fire), little private sector input or services are offered to users, thus creating opportunity for CLIMAS to fill that need. They also explicitly avoid participating in consulting work, due to the fact that equity is a foundational value of the organization whereas consulting inevitably favors some stakeholders over others. WWA set rules of engagement that shape how and with whom they engage, for example, "we make it clear that we are not consultants, and a primary WWA goal is to help NOAA learn how to provide and implement Climate Services" (p. 90) and enter into stakeholder relationships under the assumption that WWA products will be publicly available.

D. Evaluating Outcomes

Only a few of the RISAs have conducted formal evaluation of the stakeholder interactions and have instead relied on more informal evaluatory mechanisms. To our knowledge there have been no external, independent appraisals of the RISAs (i.e., non-RISA, non-NOAA). In order to assess its climate dissemination efforts, the SECC conducted a "first-order assessment of FLC [Florida Consortium] impacts, including assessment of specific climate information products that the FLC introduced from 1999 through 2002." Evaluation methods included the use of semi-structured interviews either in person or over the phone with people within the Consortium (N = 13), the Florida Cooperative Extension Service (FCES) (N = 5) and FCES personnel who underwent specific in-service training related to agriculture and climate (N = 24). The evaluation utilized several proxies in order to determine what impact the FLC efforts had on its stakeholders. CLIMAS also conducts evaluations 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" (p. 73). An additional metric for evaluation is the degree of "sustained interaction" with stakeholders, recognizing the importance of social capital in the production of useful information. Indeed, several other RISAs also utilize the frequency, duration and continued interaction with stakeholders as a proxy for success (e.g. NEIS, WWA). Many of the RISAs also seek immediate and informal feedback at meetings or workshops and query stakeholders directly regarding the utility of specific products.

IV. Few of the RISAs have formal processes for evaluating their research and planning processes, yet several engage in more informal ad-hoc approaches. NEISA for example, communicates with stakeholders and seeks input from its advisory committee (p. 50) and the Pacific RISA seeks informal feedback from stakeholders regarding "information gaps and research needs" (p. 60). One example of what appears to be a rather robust evaluation is that which CLIMAS undertook in the context of writing its proposal for renewal of the RISA grant. Specifically, they sought 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 integrating stakeholders into our research process" (p. 82). WWA views the evaluation process as involving two steps. First, they evaluate the criteria used to judge projects and then evaluate these criteria against project results, in which "ongoing stakeholder interactions and support are an obvious sign of success" (p. 91).

IV. Analysis

A. RISA approaches to Climate Science Policy

The workshop provided an opportunity to uncover and explore the variety of approaches used by each of the eight RISA programs. For purposes of analysis, it may be useful to explore the various processes that RISA programs use to reconcile supply and demand. We have identified four different approaches: stakeholder-driven research, information broker, participant/advocate, and basic research.

The *'stakeholder-driven research'* approach focuses on performing research in both the supply side and demand side in order to reconcile the two. Such efforts require robust communication in which each side informs the other with regard to decisions, needs, and products. Central to this approach is the process of identifying stakeholder's science information needs. This process is best done through an ongoing combination of formal mechanisms such as surveys and through personal queries to stakeholders. For example, SECC utilizes multiple feedback mechanisms to stakeholders not only to determine their needs, but also to inform them how SECC can meet those needs. The CLIMAS group employs social science researchers, particularly anthropologists, to assist in the needs assessment process. Additionally, they recognize the need to identify users' needs not only in terms of data, but to understand their needs with regard to the full context of the problem. Furthermore, through their experience they have come to realize that two-way, iterative, and long-term communication is essential for this process to be effective, and view their role as one of bridge-building. The dynamic of RSD is further buttressed by the recognition that this process is dynamic, or fluid. Consequently, many RISAs make explicit the need to 'capitalize on events' with regard to research decisions, and also be flexible in the roles they play depending on the situation. Intra-RISA decisions also reflect a more dynamic approach, such as with CIG, which employs a democratic process for decision making as well as consensus building among program members.

RISAs that employ the *'information broker'* approach have made the decision not to produce the scientific information themselves, either because of resource limitations, or because of lack of expertise in a particular area. Consequently, much of their efforts concentrate on providing information service support. The Hawaii RISA embodies this approach in that they are constrained by both a limited budget and the fact that program members' areas of expertise does not include production of climate science information. The program members nevertheless have a strong breadth of knowledge in the area of climate variability, resiliency and sustainability. Indeed, programs that utilize the information broker approach need members with knowledge in these areas for the simple reason that a significant amount of their time involves communicating with both science producers and stakeholders. Cultural acuity is also required in order to forge relationships across the groups. Limited resources may also drive the development of team-oriented, networking strategies they often utilize. Underlying this approach is the need to build both trust among and between groups, and credibility that comes through long-term, sustained engagement.

RISAs utilizing a *participant/advocacy* approach do so largely based on a desire to engage in a particular problem, joining with other stakeholders who are similarly engaged in advocating for solutions to that problem. For example, the NEISA program engages in the participant approach with regard to the INHALE project. They explicitly defined their roles in the group not as experts, but as participants and view their contributions as that of academics with a purpose, or as 'interested academics' who practice engaged scholarship. They also describe the process not in terms of the RSD model posited herein, but as a learning community that utilizes a dynamic of collaborative problem formulation and problem solving in a more holistic approach. Implicit in this approach is also a desire to change 'the system' and transform institutions as a means of ameliorating problems related to their area of interest. Their research priorities therefore, reflect the needs of a narrower group of stakeholders. Participation in this approach, however, still includes an iterative approach of identifying what information would be useful to solving the problem, and in designing research agendas that will facilitate solution to the problem.

At times, RISAs utilize a *'basic research'* approach, in which their research priorities are aligned more with basic research activities than with the production of applied research that can be readily used by stakeholders. This approach stems from the fact that researchers may find they are unable to produce the useful information needed by users due to the lack of fundamental knowledge about the problem. For example, the CAP identified gaps in climate modeling capabilities as a limitation to their ability to provide useful information for stakeholders, and consequently adjusted some of their research toward more fundamental endeavors.

One factor that appears to shape RISA approaches is that of institutional longevity. That is, the older RISAs appear to have more well-defined processes, guidelines, and strategies for performing their mission. For example, older RISAS such as CIG, CLIMAS and SECC have the most elaborate and involved processes for identifying and refining stakeholder's needs, and often include social scientists in this process. Younger RISAs, however, are still involved in mapping their field, so to speak, in that they are still in the process of identifying potential stakeholders, problem areas, and strategies that may work best for them. To some degree, utilizing an ad-hoc approach may well suite the younger RISA programs in that they are both searching out opportunities but also testing what approaches may work best within their organization and with stakeholder communities as a means to learn and guide future strategies. The Hawaii RISA, also young, is constrained significantly by limited resources and thus is compelled to adopt a more information broker approach rather than others. Such variation comes at no surprise given research in organizational life cycles and organization dynamics. But this does open up questions as to how the mature RISAs evolved as institutions, and of the consideration given to organizational design and management.

Perhaps the most apparent gap in the ability of the RISA programs to effectively reconcile the supply of and demand for science is that of evaluation. Only a few of the RISAs employ formal evaluations of programs and services, although some do utilize more informal, ad-hoc approaches and have gleaned valuable stakeholder feedback. Even more apparent through the course of the workshop was how little we actually know regarding the formal decision-making process regarding how RISAs set their research agendas, and whether such decisions are effective in terms of desired outcomes.

Additionally, one overarching questions remains, that is, what constitutes useful information? And, how do stakeholders utilize information? As with so many other characteristics of the RISAs, the evaluation approaches vary and indeed some RISAs have undertaken more formal surveys. However, what is needed at this juncture in the RISA history is a more systematic and comprehensive evaluation of both programs and services, and of science policy decision making.

B. Learning from the RISAs: Lessons for Climate Science Policy

The various RISA programs provide considerable evidence that the human dimensions research community has both strong theoretical and practical understandings of how to conduct research that results in the production of information considered to be useful by stakeholders. While it is clear that substantial climate science data has been produced, and has been placed in what can be thought of as a reservoir of knowledge, much of this information is not policy-relevant or useful in its present form. RISAs provide valuable services in conducting additional research and give consideration as to how best to package, present, and disseminate such information. Indeed, the RISA experience provides numerous practical lessons about how to produce useful climate science information, thus responding to the call by the US Congress and others to provide policy-relevant information for decision makers. Such lessons from the RISA programs could help expand options and choices regarding how to do climate research, and thus inform climate science policy. According to anecdotal data from RISA participants, it appears that the lessons learned from the RISA experience are not informing science policy decisions at NOAA or elsewhere. One proxy for this metric is the climate science budget that allocates just a fraction of a percent to efforts engaged in the production and dissemination of policy-relevant information. This fact illustrates that RISAs, or the RISA approach more generally, have not yet become institutionalized within the climate research community. At present, however, there appears to be only minimal momentum toward this goal, but not for the lack of effort put forth by RISA programs and its supporters in the climate science community.

V. Summary and Next steps

The RISA program experience provides valuable lessons for the larger climate science policy community. First and foremost, effective production of useful information for decision makers is about process, and several aspects of this emerged from the RISA workshop. First, early, iterative, sustained and two-way communication is essential for reconciling supply and demand of scientific information. Second, good relationships, that is, ones based on trust, reciprocity and respect - both intra-RISA and with stakeholders - is necessary to build healthy and collaborative dynamics. Third, producing good and useful information is about understanding the full scope of the problem and thus context. To identify such characteristics, RISAS must actively engage stakeholders, thus good communication and healthy relationships are necessary. Fourth, effective process must also be dynamic, resilient, and adaptive to challenges, events and opportunities. Fifth, producing useful information inevitably involves trade-offs and attempts to balance various tensions, for example, the production of knowledge vs. provision of services; public vs. private interests; public-oriented vs. peer-reviewed products; breadth of research vs. depth; demands of parent program vs. needs of stakeholder community, etc. Sixth, RISAs utilize a variety of approaches to engage with stakeholders, suggesting that there is no single 'best approach' for this kind of work. Seventh, despite the compelling evidence of RISA program success in producing policy-relevant information, these experiences have had little impact on climate science policy, yet there appears to be no easy answer as how to do so. Finally, an important next step for the RISA program is to become institutionalized within the broader climate science community.

Lessons from the RISA experience also raise further questions:

- Several different approaches exist for reconciling supply and demand, yet we know little about their relative strengths and weaknesses. What approaches work best under what conditions?
- The RISA programs explored here suggest two primary approaches to knowledge production and dissemination: do it yourself or be a broker of information. Both approaches appear to be effective, but this begs the question: what are the comparative advantages and disadvantages of each?
- Climate science policy, or the setting of climate science research agendas, is about making decisions. Yet, we know very little about the formal decision processes utilized in the RISA program for setting such agendas. How do RISAs decide what research agenda to adopt? What research to disseminate?, etc.
- Is the RISA research agenda effective and how do we know if it is?
- RISAs exhibited a wide variety of approaches to setting and implementing strategy and organizational management. What strategies do RISAs utilize to run effective organizations?
- RISA operations are often about balancing tradeoffs and tensions. How do RISAs manage these tensions and make decisions about tradeoffs?
- How can the success of the RISA program better inform science policy decisions at NOAA or at within the USGCRP?

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