AN ETHNOHISTORY OF THE

NOAA RISA PROGRAM

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Cover photo: Tom Martin. Colorado River at Havasu Canyon.

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INTRODUCTION

NOAA's Regional Integrated Sciences and Assessments program (RISA) developed from a complex mix of policy, history, personality, and serendipity. All these factors have shaped the ways in which the program has influenced climate research, climate services, its stakeholders, and the people involved in this now 20-year-old experiment in producing climate information to inform and support decision making. This report is an attempt to synthesize much of the published, unpublished, and oral history of RISA to better understand the driving forces behind the program and the foundational principles embedded in its design. Understanding the origins of the program's form and structure can help current RISA team members place the present iteration of the program in the context of its beginnings.

My goal with this research has been to collect disparate pieces of information and stories about RISA and weave them together to tell the story of the founding and foundation of the program. I make no claims about it being a definitive piece of work – there is, I think, no way to be definitive about a 20-year-old, complex, evolving organization. I have tried to represent the voices of some of the earliest members of the organization and use their perspectives on RISA to describe both the history and function of the program. Some aspects of the program have evolved over time, but there is merit in reviewing how some of the earliest pillars of the program have continued to influence its work today.

The best ethnography writes about a community in terms that its members would themselves understand and accept. That has been my goal here; I hope my interviewees (as well as those I was not able to interview) recognize the program in my description. Not everyone will agree with every characterization of the program nor every point of history I raise – that's the nature of human experience and perspectives. But I hope the description and discussion I put forth here resonate with the RISA community and perhaps provide some new insights into the program.

This report is divided into two sections. The first section provides an overview of the history of the program, exploring key events and influences that helped launch the program and set its course. The second section delves more deeply into the characteristics of the program that support its mission to "expand and build the nation's capacity to prepare for and adapt to climate variability and change."

This document is largely centered on the earliest years of the program for several reasons. First, the original impetus for an organization or program can tell us a great deal about why certain features were included (or not). And those central program features set the tone and the course of the program, although programs evolve over time. Secondly, while the climate science and climate services communities have been exploring successful modern models for transdisciplinary and climate services programs, including the current form of RISA (see for example: Lemos and Morehouse 2005; Lemos et al. 2014; McNie 2008; McNie, Pielke Jr., and Sarewitz 2007), much of the early history of the program has resided only in unpublished program documents and in the founders' memories. Documenting this *early* history, as RISA enters its third decade, seems timely.

Methods and Interviewees

Beginning in 2014 and continuing through the summer of 2016, I conducted interviews with 18 people who had been instrumental in launching the RISA program or had been or currently are program mangers or other closely affiliated individuals. I selected interview participants in two ways. First, I conducted a "historical scan" (Earl, Carden, and Smutylo 2001) with current RISA program staff in which I asked them to identify key events and individuals they felt had influenced the program. I began the interview process with those individuals most commonly recommended during the historical scan. I identified additional interviewees through chain referral sampling, in which I asked interviewees to suggest other people I should talk with about the history of the RISA program (Biernacki and Waldorf 1981).

Interview topics varied depending on the individual's role in RISA, but generally focused on questions about how and why the person had become involved in the program, their interpretation of RISA goals, examples of activities that exemplify (or fail to meet) those goals, examples of successes in the program, and a discussion of challenges facing the program. Some of the interviews represent a kind of oral history of RISA, particularly when the experiences of the individual have not been captured in other RISA documents.

Interviews took place in person when possible, or by phone when travel was not feasible. In some cases, follow-up questions were answered via email as a matter of convenience. Interviews were transcribed and coded into categories reflecting the broad themes outlined above. The interviewees cited in this document (with dates interviewed and in alphabetical order) are:

- Otis Brown (August 24, 2016)
- Jim Buizer (March 18, 2014; April 30, 2015)
- Daniel Ferguson (June 13, 2015)
- Josh Foster (via email; August 22, 2016)
- Gregg Garfin (June 13, 2015)
- Michael Hall (June 20, 2014)

- Harvey Hill (July 14, 2016)
- Diana Liverman (June 17, 2015)
- Nate Mantua (September 29, 2015)
- Richard Moss (May 27, 2015)
- Barbara Morehouse (July 10, 2015)
- Claudia Nierenberg (December 8, 2014)
- Adam Parris (February 4, 2015)
- Roger Pulwarty (February 6, 2015)
- Edward Sarachik (September 10, 2015)
- Eileen Shea (February 20, 2015)
- Caitlin Simpson (December 9, 2014)
- Amy Snover (October 7, 2015)

I also explored published and unpublished documents related to the program, such as internal reports, government reports, congressional testimony, and the peer-reviewed literature. Using a similar coding process as described above, information from the documents was coded into the broad themes.

As is common in social science research, although the code list started with defined themes, these evolved and expanded over time to incorporate new ideas or concepts that emerged from the research (see for example, Altheide 1987).

CHAPTER ONE: RISA ETHNOHISTORY

In this section, I discuss some of the events and experiences that contributed to the launch of RISA. After reviewing the pre- and early history of the program, as it developed in the NOAA offices, I describe some of the key events in the creation of the first two RISA projects – the Climate Impacts Group (CIG) and the Climate Assessment of the Southwest (CLIMAS) – as well as trace the build-out of the RISA program to its current cohort of ten teams.

Several interconnected factors influenced both the launch and evolution of RISA. First, the science-management philosophy in the various offices run by J. Michael (Mike) Hall leading up to the founding of RISA created a culture that favored experimentation and innovation. Secondly, scientific innovations in climate research, including improved skill in forecasting natural climate phenomena such as El Niño, allowed researchers to more readily consider the possibility of supporting real-world decisions with their science. Third, the creation of the U.S. Global Change Research Program (USGCRP) in the late 1980s provided first an opportunity for Hall and NOAA to take a leadership role in federal climate science, then a venue in which to focus on climate science in service of society. A fourth influencing factor was the experience that Hall's NOAA Oceanic and Atmospheric Research program (OAR) staff gained through their development of the International Research Institute for Climate and Society (IRI), which provided a venue to experiment with creating a climate service entity. Finally, innovations in the field of social science made OAR program managers more receptive to its value within climate research and more willing to explore its use in linking science with decision making.

Groundwork for a New Approach to Climate Research

In the early 1980s, Mike Hall (retired), the eventual founder of what would become the RISA program, was in NOAA's Global Atmospheric Research Program (GARP), where he was managing the U.S. portion of the World Climate Programme's Tropical Ocean Global Atmosphere (TOGA) program. TOGA established an ocean-observing network to support seasonal-to-interannual climate studies, spurred by recognition of the widespread and systematic influence of El Niño-Southern Oscillation (ENSO) on the ocean-atmosphere system (McPhaden 1998). TOGA's contributions to climate science include identifying predictability in the climate system and considering how predictions could be used for societal benefit (ibid).

During his time in GARP, Hall was laying the groundwork to link climate research to human decisions at national and international scales. His work there presaged a developing interest in systems-thinking as a way to understand and approach complex problems. For example, Hall tasked a staff member – Pete DeRegt – with outlining a climate observing system. To Hall's surprise – and delight – DeRegt created a conceptual model that included, in addition to the scientific observation equipment and programs, U.S. Congress and other human institutions (Figure 1).

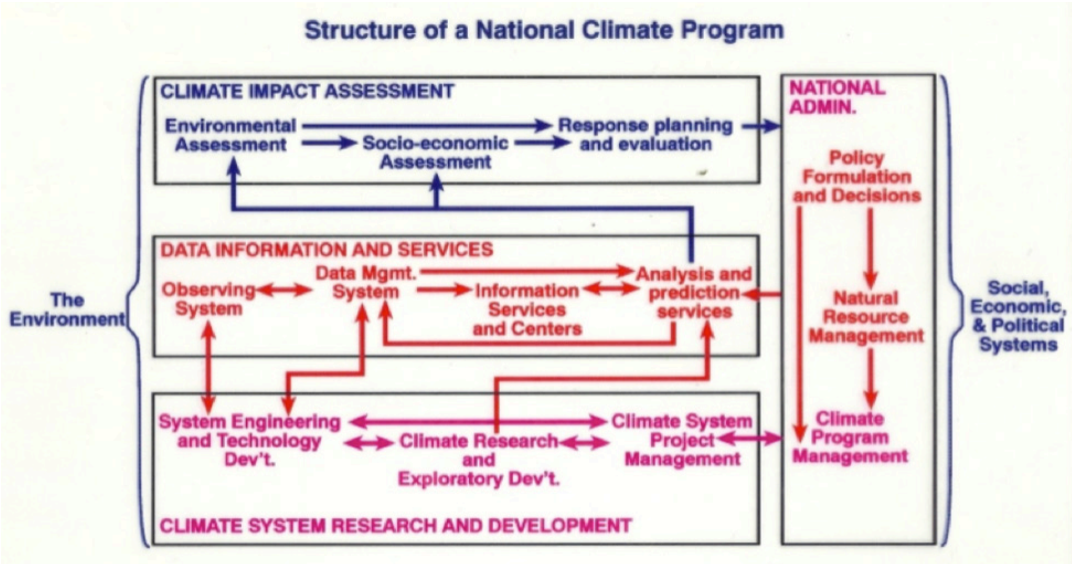

Figure 1: Early conceptual model of a national climate program. Attributed to Pete DeReget circa 1984.

"It just blew me away. Knocked me right out of my chair," said Hall. According to Hall, DeReget maintained that without both the funders and users of the observations, the system would not be complete or sustainable. DeReget explained to Hall, "Every few years someone proposes cutting the operational satellites, for example. So you do you think it's researchers that bail it out? Do you suppose it's just that Congressmen like satellites? Nope – it's the guy who uses the weather forecast who goes to Washington and kicks butt and says 'Keep those up there.' And they stay up there. The stabilizing factor in an observing system is the users and funders!" "I had never thought about an observing system that way," Hall recalled. Hall admitted, however that "it took me five years to assimilate this idea."

Throughout the history of RISA there are echoes of these two concepts: that climate science can be of help in solving real-world problems and the recognition that the systems involved—the climate system, social systems, and political systems—are interrelated.

Scientific Influences

In 1986, Mark Cane and Stephen Zebiak's ENSO model was used to successfully predict that year's El Niño event. The model also proved successful over the next several El Niño occurrences, providing predictions over a year in advance. The ability to predict El Niño, which can be extremely destructive phenomenon in certain parts of the world, opened up new possibilities for helping people to adapt to the negative effects of this climate pattern. The same year that the Cane-Zebiak model was released, Mike Hall approached Jim Buizer (University of Arizona Institute of the Environment), who had come to NOAA as a Sea Grant Fellow two years before, with the idea to travel to the "epicenter" of El Niño impacts—Chile, Equador, and Brazil—"to find out if [the model] is even useful for humans." Buizer readily agreed. On the return flight, Hall asked Buizer to come to work for him at OAR and establish a program focused on El Niño impacts (and those from climate variability in general) in the places most affected by the phenomenon.

The next year, in testimony before the U.S. Congress, Hall laid out the argument for the importance of the breakthrough in ENSO predictions by noting that, "had we been able to predict the 1982-83 El Niño, the U.S. could have saved $20 billion in agricultural subsidies" (Global Environmental Change Research 1987, 112). Hall's testimony continued to stress the importance of harnessing climate research to be "applied to the pressing human problems we now encounter" (ibid).

In 1990, the NOAA OAR became the Office of Global Program (OGP), but the new office continued the work of linking climate forecasts to decision-making. In 1991, OGP started its Pilot Program for Application of Climate Forecasts, which worked in the health sector across Latin America, Southeast Asia, the South Pacific, and Southern Africa to produce and distribute climate forecasts for extreme climatic events (Buizer, Foster, and Lund 2000). Another experiment in linking climate prediction to regional decision-making was the Climate Outlook Forums that OGP developed as part of its effort to work in international communities impacted by El Niño (Buizer, Foster, and Lund 2000). The forums brought climatologists and meteorologists, who created regional, consensus-based forecasts, together with representatives of climate-sensitive sectors, who discussed options for applying the forecast information.

Influence of USGCRP

The creation of the USGCRP in 1989 stabilized one portion of the climate research and services system by establishing the program under federal law, designating key roles within a subset of federal agencies, and providing funding for the enterprise. Both the negotiations leading up to and the eventual creation of the USGCRP contributed to the development of RISA by carving out a role for NOAA as both a leader and innovator.

Lambright (1997) points to the confluence of several streams of thought on climate research and policy that helped to create the USGCRP. He explains that by the mid-1980s, the largest federal science agencies had all taken on roles in the larger enterprise of climate research. NASA had taken on the task of studying earth as a system through its Mission to Planet Earth. NOAA was exploring natural climate variability and societal impacts as a key focus area. The National Science Foundation (NSF) was committed to continuing its focus on basic geosciences research. The Department of Energy (DOE) and the Environmental Protection Agency (EPA) each carved out roles specifically in global warming research. Lambright also cites the 1987 Montreal Protocol and then-President Ronald Reagan's questions about global warming as additional factors that contributed to the first stage of what would become the USGCRP.

In 1987, Presidential Science Advisor William Graham created the interagency Committee on Earth Sciences (CES) and tasked it with establishing a global change research program. Interagency struggles threatened to derail the program almost immediately until Shelby Tilford (NASA), Robert Correll (NSF), and Mike Hall stepped up to save the program. The three senior managers negotiated a budget agreement with the Office of Management and Budget (OMB) to jointly fund the new program, with each of the agency's budgets tied to the others to ensure that the program was egalitarian and not a threat to any one agency's interests (Lambright 1997). Eileen Shea (NOAA Pacific Islands Regional Coordinator), who would go on to become Hall's deputy director in OGP and later launch the Pacific RISA, was the OMB budget analyst assigned to help Hall with his early budget proposal. The result of the negotiation was the creation of the USGCRP in 1989.

NOAA had created OGP as part of its contribution to the USGCRP (Pulwarty, Simpson, and Nierenberg 2009). While OGP's goals reflected those outlined by the CES in its 1991 *Our Changing Planet* document—integrate science into the policy process, maintain a partnership among all participants, and focus on interdisciplinary science and interactions (Committee on Earth Sciences 1988)—internal OGP documents note that they interpreted these guidelines quite differently from other USGCRP participants. Based on their experiences with the TOGA program, OGP staff "observed how merely forecasting El Niño events was not sufficient for decision makers to respond effectively. They realized at an observational level that effort would have to be expanded to develop more effective links between the end-user and the forecaster" (Hill 2001, 4). They chose, as a result, to be more interactive with decision makers than was conceptualized in the CES goals. Secondly, OGP chose to focus more on climate variability than change. "They concluded that the ability to predict seasonal variability, and the relevance for decision-makers of seasonal forecasts, was greater in the early 1990s than was the case for long-term climate forecasts" (Hill 2001, 4).

The USGCRP helped to support the early activities of what would become RISA in a second way as well. The same act that created the USGCRP (U.S. Global Change Research Act *Public Law 101-606 104 Stat. 3096-3104, 1990*) also created a mandate for the National Climate Assessment (NCA)—a synthesis and analysis of climate science and climate change impacts in the United States that must be produced every four years. Several RISA teams, in the late 1990s, contributed to the first NCA[1] report and used the convening activities surrounding it to clarify stakeholder needs in their respective regions and inform their nascent research agendas (see for example: Merideth et al. 1998).

Hall recalled that his vision for OGP was that it would become a national climate service.[2] "It was a consequence of that early view of 'What is an observational system? How does it do its analysis? Who is that analysis for? And what stabilizes and funds the system?'" He hoped to grow the program into a $140 million per year program.

CRITIQUES OF USGCRP AND OTHER FEDERAL RESEARCH PROGRAMS

The purpose of the USGCRP is to "provide for development and coordination of a comprehensive and integrated United States research program which will assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change" (*Global Change Research Act of 1990*). However, in the early 1990s a number of reports were critical of federal environmental research, including the USGCRP, and its relationship to policy, finding a lingering disconnect between federally funded research and its application to policy- and decision-making.

The 1993 Office of Technology Assessment (OTA) report, *Preparing for an Uncertain Climate* (U.S. Congress 1993), acknowledged the challenges of integration that research programs continue to wrestle with today (see for example: Cvitanovic et al. 2015; Clark et al. 2016; Lemos, Kirchhoff, and Ramprasad 2012; McNie 2007) by stating, "Research programs intended to be relevant to management and policy making often fail because of fundamental tensions among researchers, resource managers, and decision makers. These tensions are created because of conflicts in the time horizons of each group, differences in priority—or goal-setting processes, and differences in the agendas of extramural research organizations, mission-oriented agencies, and Congress" (U.S. Congress 1993, 117). But ultimately the report stressed the need for a policy orientation within USGCRP: "Identifying the outcomes that matter to policy makers should be the first step in refining global change research programs" (U.S. Congress 1993, 145).

The Carnegie Commission issued a similar report, *Science, Technology, and Government for a Changing World*, in which they noted "the existing federal environmental research programs were built for another time and for a set of issues that no longer correspond to today's environmental priorities." They recommended that federal research programs be better coordinated and emphasize multidisciplinary research; they should foster closer ties between scientists, non-governmental organizations, and industry to better coordinate disparate efforts; and there should be more involvement of major sectors of society in setting the science research agenda. "Scientists alone cannot develop these goals; a coordinated effort by a cross-section of society is essential" (Stever 1993, 70).

In 1994 the House Committee on Science, Space and Technology held hearings focused on the state of federal environmental research and its role in informing decision making (Federal Environmental Research 1994). The committee chairman, George E. Brown Jr., explained the rationale behind the hearings:

> Environmental problems once described in terms of local pollution events have given way to effects felt on a regional or even global scale. Global environmental problems such as climate change, stratospheric ozone depletion, and the loss of biodiversity challenge the sustainability of human and natural systems, and all too often the response of environmental scientists today is the same as it was 20 years ago: We need to do more research before we can act . . .
>
> It is our goal to pursue a policy that ensures a sound scientific basis for responsible decisionmaking, and this requires that the Committee ensure that the R&D programs of each agency and the whole enterprise is properly organized, that mechanisms exist to ensure that research is targeted at the right issues, that the research which is conducted is of the highest quality, and that mechanisms exist to ensure the use of the research results in decisionmaking . . . (Federal Environmental Research 1994, 1-3)

Two concepts emerged in testimony in this hearing that would later appear in the RISA program. First, James Baker, then-NOAA Administrator, suggested creating direct connections between stakeholders and researchers in order to identify research priorities: "One of the best mechanisms to ensure quality control is

[1] RISA teams remain key contributors to the NCA; RISA investigators are often NCA quadrennial report coordinators and authors.

[2] Several interviewees who were in OGP at the time recall Hall's desire to move beyond just a climate service into a broader environmental service organization that could provide monitoring and supply information on a range of environmental variables.

to encourage and facilitate the participation of stakeholders and a wider external committee in identifying the right issues [for federal research focus].” Second, John Gordon, from the Yale School of Forestry, articulated a vision for federal research that involved “creating a number of centers where scientists and policy makers work together to identify emerging issues and to marshal the science base by searching the existing research community and the existing literature that would be useful in resolving the issues so identified” (Federal Environmental Research 1994, 24).

A third concept—that of regional assessments as a useful approach for delivering climate research—also grew out of the critiques of USGCRP. As early as 1991, Rubin, Lave, and Morgan (1991) critiqued the USGCRP for being too focused on scientific inquiry, “not policy issues” (p.50), and called for the use of integrated assessment to survey the state of knowledge on climate change and serve as a bridge between the scientific and policy communities. The 1993 OTA report specifically noted that there was no mechanism for the USGCRP to provide information to policy makers (U.S. Congress 1993). The report recommended that the USGCRP use integrated assessments as an approach to make its research more usable. “Although the program is scientifically well-grounded, it has become overwhelmingly a physical science program focused on basic Earth system processes that largely ignore the behavioral, economics, and ecological aspects of environmental problems,” wrote the report authors (U.S. Congress 1993, 110). In response to these critiques, regional assessments were added to the USGCRP portfolio in 1994.

While it is not possible to draw a direct link between these broader discussions about the role federal environmental and climate research does, or should, play in decision making and the creation of the RISA program, it is clear that in the early 1990s the broader science-policy community—including Congress—was looking for tangible ways to ensure that federal research dollars could have maximum impact.

International Influence

The links between RISA and the international programs associated with NOAA are rich; NOAA’s early participation in international efforts to use climate information to mitigate disasters paved the way for the development of national programs such as RISA. First, NOAA’s participation in TOGA made it part of the international, transdisciplinary discussions about the potential uses for climate prediction information. The ideas that grew from TOGA included creating processes to translate climate research into regional applications, decision-support services, and early warning networks (Vaughan et al. 2014). Second, Hall and Buizer were committed to exploring the usability of climate forecasts for real-world decision making, particularly in those regions of the world most vulnerable to El Niño. It was on the return from their trip to Latin America in 1986 that Buizer and Hall first sketched out the ideas for a centralized institution that would generate and assess seasonal climate forecasts, then disseminate them to regionally grounded programs that could get them into the hands of decision makers. This idea would eventually take form in the International Research Institute for Climate Prediction (IRICP) in 1995. Hall and Buizer both explicitly cited IRICP and its structure—i.e., a series of regional centers united by a centralized science unit—as a prototype for RISA. As discussed below, RISA in fact evolved slightly differently, in part because of lessons learned through the IRICP experience.

With its initial focus on international climate research, IRICP allowed the OAR[3] staff to avoid certain constraints of building a domestic initiative, according to Buizer. First, there was some concern by other offices in NOAA that forecasting was “their” responsibility—not OAR’s. Moving to an international focus allowed OAR to avoid stepping on their intra-agency partners’ toes. A focus on “research” as opposed to operational forecasting also allayed the concerns of the international forecasting community. IRICP could be viewed as a test bed rather than a competing organization. IRICP became the IRI for Climate and Society (IRI) in 2005, when its mission shifted to include research into the socio-economic impacts of climate information (Vaughan et al. 2014).

The creation of IRICP and OAR’s other international connections provided opportunities to test many of the ideas that had been circulating in OAR/OGP, including how to systematically link climate science with real-world decisions and how to understand the process of delivering information to regional decision makers. Buizer summarized some of the key lessons he felt the OAR/OGP staff took from their international experience. First and foremost was the necessity to start with information about which scientists could be certain. At the time, that certainty occurred in the realm of climate variability—particularly ENSO, as opposed to longer-term climate change trends. Secondly, the program needed to focus on the demand side of the partnership: information that on-the-ground decision makers needed and cared about. By engaging with non-academics, the climate scientists could learn directly from farmers, water managers, emergency managers, and other decision makers about the impacts of El Niño and their information needs. Claudia Nierenberg (NOAA Climate Program Office), who came to OAR in the late 1980s after working in the international affairs office of the Treasury Department, described the process of integrating end-users as “creating a mixing bowl of science and modeling with local knowledge . . . you could create mechanisms and methodologies to understand people’s development pathways . . . Under what conditions is predictive information that is probabilistically created useful? Who would use it? What would they use it for?” Buizer recalls observing the mix of meeting participants change over time from being dominated by scientists to, eventually, a 50/50 split between scientists and end-users of climate information. Finally, the team learned that the centralized structure of the IRI actually inhibited the researchers’ ability to fully engage with regional decision makers and it shifted to a decentralized model when it became time to start a domestic program.

[3] The NOAA office responsible for the IRICP was Oceanic and Atmospheric Research (OAR) at the time of its conceptualization, but was re-named Office of Global Programs (OGP) by the time IRICP was founded.

Integration of Social Science

Prior to the early 1990s, NOAA social science research focused on economics (Hill 2001). As conversations about the application of climate research to societal decisions swirled in the broader climate research community, Mike Hall and OGP more generally began to explore the role of social science in climate-related research and applications. Buizer recalls early "dabbling," in social science, such as during a 1989 meeting in Fortaleza, Brazil, the first time they invited a social scientist—Mexican geographer, Roberto Sanchez—to one of the El Niño forums. However, two key elements that influenced the use of social science in RISA were the OGP advisory committee (the Global Change Committee) and hiring Nierenberg, who brought with her a background in political science and experience working in the Treasury Department.

It was through the Global Change Committee that support for social science work was institutionalized in OGP. Committee members included Otis Brown (chair), Mickey Glantz, and Diana Liverman, who joined in 1993. Starting in 1991, OGP funded several human dimensions studies. Early requests for proposals focused heavily, but not exclusively, on coastal communities; the identifiable threat of sea-level rise made coastal impacts a high priority (Hill 2001). Liverman (University of Arizona School of Geography and Development) recalls the committee discussions that helped to push OGP to fund more social science research on the impacts of climate variability and change and the use of climate information in decision making.

> At my very first meeting, Mike was going through the budget . . . and a lot of it was going to the early ENSO prediction stuff and GFDL (Geophysical Fluid Dynamics Laboratory). I asked him how much money was allocated for social science. And he told me $300,000 or $500,000. I was pretty cheeky and said 'Well, I don't understand the point of me being on the committee if that's your pathetic contribution to social science.' And he said 'How much should I be spending?' And I said '$5 million'—I just sort of made it up. That got a conversation going . . .

Hall continues the story with his explanation of why he was open to funding social sciences out of OGP.

> People will tell you that for whatever reason in the middle 1990s Mike Hall got interested in social sciences and the bastard started funding some! They were up in arms against me, the physical scientists. But, I had a theory that, this business of people and people in decision making, that's not physical sciences, that's social sciences. . . [And the social science pieces] would fall through the cracks in [USGCRP] because that wasn't anyone's job. . . . The stovepipes are too vigorous.

Other social science work that focused on the links between science, society, and policy-making has influenced the ways in which RISA both operates and defines itself. Beginning in the early 1980s, social scientists began to interrogate the supposed boundary between science and society and the value of the boundary to each group (Gieryn 1983). But, as recognition of the need to combine natural science and social science in the service of real-world problem solving took hold, researchers began to look at ways to make the boundary more permeable in certain situations (Fujimura 1992; Star and Griesemer 1989). Later, the idea of boundary organizations—unique groups with the ability to both maintain and negotiate the boundary—emerged as potentially important components in addressing environmental problems (Guston 2001). It is not clear from OGP documents whether this line of research directly influenced its approach to creating RISA, but interviewees noted the parallel development of the program and the field of research. Eileen Shea noted that she observed RISA program staff "see that these emerging ideas [boundary organizations] had merit . . . and begin to embrace them and build them in" [to their work].

In 1993, OGP created a request for proposals focused on the human dimensions of climate variability and change; they sought research that could develop a greater understanding of human adaptation to past climate variability (Pulwarty, Simpson, and Nierenberg 2009). The first RFP included the following statement, indicating that OGP was already moving toward the idea of regional assessments: "A new area of emphasis will be comparative regional integrated assessments addressing climate change and other environmental problems of significance to the region." OGP's turn toward social science had opened the door so that when in 1994, a proposal by Edward L. Miles of the University of Washington (UW) to explore climate impacts on a regional scale, made its way via NOAA Administrator James Baker, to Mike Hall in OGP, it struck a chord.

Climate Impacts Group—The First Regional Integrated Assessment

The 1994 disaster declaration and closure of Columbia River salmon fisheries was a precipitating event in what eventually became a proposal for the first RISA program: the Climate Impacts Group (CIG). This was the first disaster to be attributed to ENSO (made in response to the 1992-93 El Niño; Pulwarty and Redmond 1997; Smith and Gilden 2000); however multiple stressors are recognized as having contributed to the salmon decline, including hydropower dams, habitat degradation, and poor management (Pulwarty and Redmond 1997; Smith and Gilden 2000). The strain on the salmon fisheries brought the issue of climate variability to the forefront in the region, providing an opening for Ed Miles' proposed research on the impacts and policy responses to climate variability in the Pacific Northwest.

The original proposal from Miles was solicited directly by James Baker, who was at the time the NOAA Administrator. However, after Miles submitted his proposal, Baker found he did not have sufficient funds to support it on his own and began circulating it through NOAA offices. It eventually came to Hall in OGP. Buizer, who had studied with Miles at UW, recounts receiving the proposal: "I knew Ed and I trusted Ed. Both Mike and I are that way: we trust the people . . . so we knew that it was going to be good."

Miles, a co-founder of UW's Institute of Marine Studies, brought to the field of climate research his background in history, international relations, and management of common-pool resources. In the words of Amy Snover (University of Washington), one of CIG's earliest associates and its current director, Miles built his career working on wicked problems. Ed Sarachik, one of Miles' colleagues at UW, remarked on his long history of promoting collaboration in his research work.

Just after his original proposal to James Baker, Miles became involved in the Intergovernmental Panel on Climate Change (IPCC). He grew frustrated with the scale of analysis – he felt that the regions defined by the Panel were far too large to be meaningful for decision makers and the lack of integration between the working groups reduced the usefulness of the science (Hill 2001). Miles' 1995 version of the proposal for what eventually became CIG attempted to address both of these shortcomings by focusing on a geographic scale that was meaningful to regional decision makers, through a process of integrated assessment that tied together climate information, region-specific impacts, and decision-making.

Buizer, Nierenberg, and Hall worked with Miles to refine the proposal, suggesting an increased focus on ENSO and climate variability and a tighter connection with regional climate stakeholders. The OGP program managers proposed and supported a workshop held at the NOAA Pacific Marine Environmental Laboratory (PMEL) in February 1995. The workshop brought together climate researchers from NOAA and the Joint Institute for the Study of Atmosphere and Oceans (JISAO) at UW and representatives of users of climate information in Washington and Oregon (Miles 1995). Outcomes from that workshop were incorporated into Miles' revised proposal to NOAA, *Integrated Assessment of the Dynamics of Climate Variability, Impacts, and Policy Response Strategies for the Pacific Northwest: A Research Design*, which was submitted in 1995. In the proposal, Miles outlined two research foci: a) applying predictions of climate in the Pacific Northwest and b) an integrated assessment of climate variability impacts in the Pacific Northwest, both as a model for potential climate change and as an economically practical use of current scientific knowledge of seasonal to inter-annual climate variability. The phrase CIG staff use to explain their approach to integrated assessment is "end-to-end research," which allows them to look at information, impacts, and responses across four key sectors: water, forests, fish, and coasts. The proposal summarized the climate information needs and decision contexts of several key user groups in the region, including the Washington Department of Fish and Wildlife, Seattle City Light, and the Northwest Power Planning Council, gathered through a February 1995 workshop.

According to some of the earliest CIG staff, Miles operationalized his views about collaboration immediately. He used a portion of funds to pay summer salaries for five senior faculty members at UW. He asked them to attend weekly seminars to talk about their research interests. Nate Mantua (NOAA National Marine Fisheries Service), who was hired to work with CIG in fall 1995, recalled that after about four months, the group "started to realize that there was a lot of low-hanging fruit for us to really grapple with and dive into and start to tell the story." Those early meetings—and the ensuing collaborations—continued for years. "It was an exciting place to be, with new knowledge that's relevant and applied," recalled Amy Snover. Team continuity was also important, explained Snover. "To build a team that works together, you've got to agree on the words you use, and how you use them. That takes a lot time to develop . . . you can't just start from scratch and build new teams. We definitely had new PIs come in, but we never had a wholesale new team. I think that allowed us to continue to build on the understanding that we'd developed together . . . and to continue, to deepen and strengthen all of our stakeholder relationships."

The goal of the CIG, from its earliest days, was to make climate information usable and useful. The staff did this by working directly with stakeholders in the region and committing to the end-to-end model of assessment. Nate Mantua supplied one example of this philosophy in action. Alan Hamlet and Dennis Lettenmaier were leading work to develop future streamflow scenarios for the Columbia River basin. They used a hydrologic model of the Northwest and ran it using future climate projections to simulate the evolution of the region's hydrology and streamflow. Then they took their model to a meeting of regional resource managers, including water managers. However, Mantua explained, "the [water managers] said 'That's interesting. It's totally useless to me." The water managers explained that their decisions were tied to streamflow in the specific parts of the basin they managed and not just the mouth of the Columbia Basin, as was presented in the research report. Because of this feedback, the CIG team developed streamflow projections for many of the sub-basins within the larger Columbia Basin. Some of these results are included in Miles et al. (2000), which demonstrates the end-to-end assessment approach originally outlined in Miles's 1995 proposal. Mantua recalled this project was a breakthrough for him on the importance of making a direct connection between research and the decisions people are making.

Amy Snover continued the narrative of the streamflow projection project. She noted that the information gathered was used, for example, in a 2001 region-wide workshop for water resource managers intended to catalyze a regional response to risks posed by future streamflow changes. From these efforts, the CIG team recognized the need among decision makers for information tied to specific gauges in the Columbia Basin, and undertook work to provide that data (Snover, Hamlet, and Lettenmaier 2003).

Perhaps the best-known scientific breakthrough to come from CIG was Mantua and colleagues' (1997) identification of an interdecadal climate pattern—the Pacific Decadal Oscillation (PDO)—as a significant driver of salmon production in the Pacific Northwest. The authors used climate records, combined with historic records of biological variability in the region's marine ecosystems to uncover a previously unknown climatic phenomenon and simultaneously identify its social and economic impacts on the region in the form of the size of salmon runs and harvests. Another CIG innovation was the 2007 report, *Preparing for Climate Change: A Guide for Local, Regional, and State Governments*, which provides decision makers with step-by-step instructions for assessing climate change-related risks and developing sound adaptation strategies. The guide was produced in collaboration with ICLEI, who has distributed it to more than 250 cites, towns, and municipalities (Snover et al. 2007).

In 2002, at a congressional hearing focused on the federal government's climate research and technology programs' ability to yield information useful to decision makers, Ed Miles spoke on behalf of the RISA program.[4] He described RISA as "the last link in the chain which connects the basic research based on observations and modeling to real people and their interests in real places" (New Directions for Climate Research and Technology Initiatives, 2002, 40). Miles continued on to explain that RISA was the only federal research program "centrally focused on and systematically produc[ing] *climate* (as opposed to weather) [information]" that is needed by consumers such as regional resource managers (New Directions for Climate Research and Technology Initiatives, 2002, 58)

Mantua recalls his time at CIG and with Ed Miles fondly, "[Ed] created a really special space for early career people like me and Phil [Mote] and Amy [Snover] and Alan [Hamlet] and Lara [Whitely Binder]. . . to do some really exciting, fun science."

In 2010, the RISA regional team moved from UW to Oregon State University, where former-CIG postdoctoral researcher Phil Mote is now the principal investigator for the Climate Impacts Research Consortium (CIRC). However, CIG, as a stand-alone program at UW directed by Amy Snover, has continued to serve regional stakeholders including the City of Seattle and King County, tribal communities throughout the Northwest, and federal agencies such as the Federal Highway Administration.

The Southwest Assessment

The University of Arizona's ties to the RISA program are almost as old as those of UW. During her tenure on NOAA's Global Change Committee, Diana Liverman moved from University of Wisconsin to the University of Arizona. The UA was already on OGP's radar because of its history of interdisciplinary research, especially along the U.S.-Mexico border. The UA's Udall Center for Studies in Public Policy was of particular interest because of its "unique capability to work effectively between the policy-making community at the local, state, and federal level, and academic scientists grounded within specific programmatic foci" (NOAA - Office of Global Programs 1997). The 1996 drought in Arizona was also a driver of NOAA's interest in the Southwest, according to Liverman; it created political motivations for funding climate work.

In January 1997, representatives from OGP undertook a site visit to UA to hear directly from researchers about their work and connections to the decision-making community. At the meeting, the OGP and other NOAA representatives (who included Hall, Neirenberg, Buizer, and Caitlin Simpson) heard presentations from, among others, Soroosh Sorooshian (UA Hydrology and Water Resources), Diana Liverman (UA Geography and Regional Development and Latin American Area Center), Bob Varady (Udall Center), and Roger Bales (Hydrology and Water Resources and Institute for the Study of Planet Earth). The decision-making community was represented by Jon Skindlov and Dallas Reigle from the Salt River Project as well as several people from the USDA.

The meeting agenda included an explanation of OGP's interest in regional integrated assessments:

> …the emerging realities of more frequent incidents of
>
> extreme events and associated pressures within federal budget making place increasing importance upon our ability to demonstrate the relevance of global change research. There is growing sensitivity to the fact that many sources of change are global, yet people experience change/variability at local and regional levels. As managers of federal dollars, we now have an expanded responsibility to determine how to translate the results of research intended to advance understanding about global change into information relevant to decision-makers, government officials, and the general public.

The goals of the meeting were to define the regional issues around which a Southwest assessment would be organized; discuss the research-based resources necessary to address the identified issues; and discuss the nature of the assessment as a mechanism to apply the results of research to the improvement of resource management.

Original notes taken during the meeting captured the content of Mike Hall's presentation on the goals of the new integrated regional assessment initiative. He described his goal of creating an agency that would provide information on long-term climate changes (decadal to centuries) in combination with both weather and interannual climate information and link this regional climate information with human dimensions research and the creation of applications in such a way that all "franchises" would interact with each other (Figure 2).

[4] In 2002 RISA consisted of five teams: CIG, Climate Assessment for the Southwest (CLIMAS), Southeast Climate Consortium (SECC), California Applications Program (CAP), and Western Water Assessment (WWA).

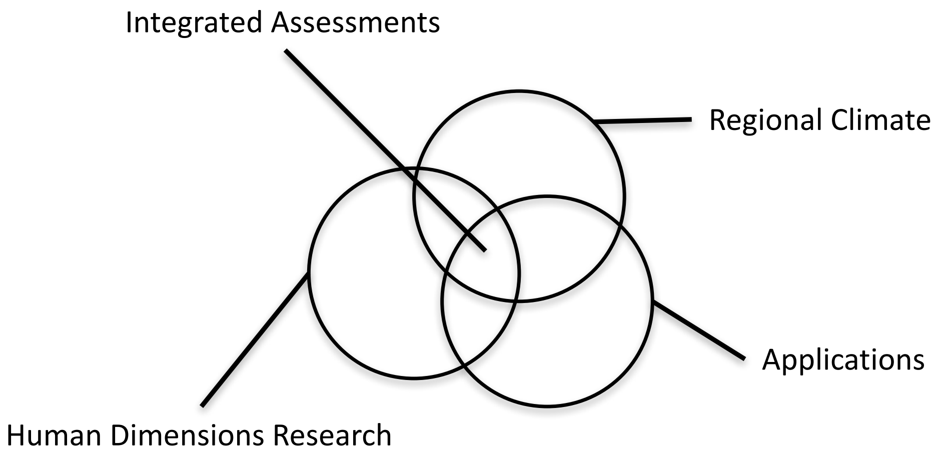

Figure 2: Re-creation of Mike Hall's conceptual model of integrated assessments

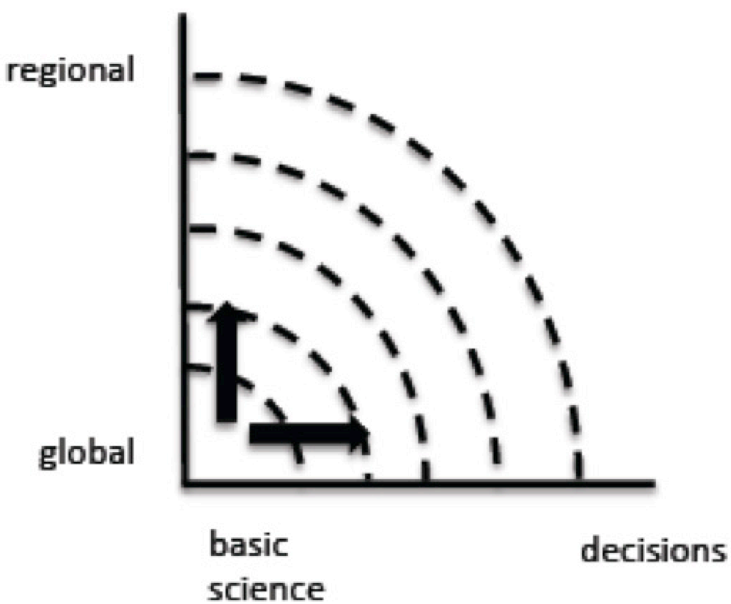

Figure 3: Re-creation of Mike Hall's conceptual model of the movement of OGP's focus from basic and global-scale to decision-based and regional scale work.

He also described his office's goal of moving from global-scale basic science to regional-scale science focused on decisions (Figure 3).

A few months after the site visit, in September of 1997, UA played host to the Southwest Regional Climate Change Symposium and Workshop, a meeting funded by the Department of the Interior and the USGCRP on climate change and variability in the Southwest as part of the build-up to the First National Climate Assessment, which was released in 2000. Similar to the workshop hosted by Ed Miles at UW prior to launching his assessment, the intent of the symposium was to "bring together important stakeholders to determine the state-of-knowledge, information and research needs, and possible policy strategies related to the impacts of and responses to climate variability and change in the Southwest" (Merideth et al. 1998). The symposium participants and organizers compiled a set of recommendations that covered scientific priorities for the region, called for the inclusion of *assessments of decision-making processes*, and asked for data derived from the research activities to be both stored and made accessible.

The initial funding for CLIMAS came in February 1998 with Roger Bales, Soroosh Sorooshian, Timothy Finan, and Diana Liverman of the University of Arizona acting as principal investigators. The first pulse of funding allowed the research team to establish a core office, which was led by Barbara Morehouse as program manager. The core office served as the organizational focal point for the team's work as well as for outreach to stakeholders (Morehouse 2000), an innovation which has since been adopted by all the RISA projects. Research began in late spring and focused on a detailed needs-assessment of regional stakeholders, which built on recommendations from the 1997 symposium. The combined information formed the basis of CLIMAS's research agenda (Morehouse 2000).

Early CLIMAS research focused on six areas: climate variability, seasonal forecasting and evaluation of forecasts, urban water management, ranching, Native American communities, and border communities. Research subsequently undertaken on climate variability in the region resulted in an overview of the Southwest climate (Sheppard et al. 2002) and studies that linked climate variability and the incidence of Valley Fever (Kolivras et al. 2001), including a working forecast model of the disease for Pima County, Arizona (Kolivras and Comrie 2003). Research linking climate variability and change to disease vectors continues to be a key component of the CLIMAS portfolio (see for example, Brown et al. 2014). Collaborations with Native American communities also started in the earliest CLIMAS iteration (NOAA Office of Global Programs 2000) and have continued throughout the lifespan of the team (Austin and Wolf 2001; Ferguson, Masayesva, et al. 2016).

An early summary of RISA project work, *Regional Climate Assessment and Science: A Call for Action*, called attention to the way in which CLIMAS climate science developed from the process of working with stakeholders in the region (NOAA Office of Global Programs 2000). For example, questions from water managers led to CLIMAS research projects focused on regional snowpack and the North American Monsoon. Barbara Morehouse described the process of working with water managers in the early days of CLIMAS, before climate data was a common tool for managers.

> The stakeholder meetings—it was a learning process. The first ones we held, there was a lot of skepticism; people said "I've got the weather, what else do I need?" Trying to get them to think more about even seasonal climate variability, especially water managers—either it rains or it doesn't. "It's never dry in both the upper and lower Colorado Basins"—I was told that by someone at [a water management agency]. There was a lot of convincing. And you couldn't go into one meeting and do it. You had to go back and back.

The experience of CLIMAS researchers collaborating directly with regional resource managers to produce usable science was summarized in a seminal paper by Maria Carmen Lemos and Barbara Morehouse, *The co-production of science and policy* in integrated climate assessments (Lemos and Morehouse 2005) and has formed the basis of several efforts to evaluate the effectiveness of scientist-stakeholder collaborations and the delivery of climate services (Ferguson, Finucane, et al. 2016; Guido et al. 2013).

CLIMAS is now the oldest continuously funded RISA project.

Pilot Project Build-Out

The next regional assessment project to be funded by OGP was based at University of Florida and led by Jim O'Brien. It focused heavily on climate impacts to the agricultural industry of the Southeast. O'Brien had been unsuccessful in a proposal for the IRI, but because the proposal was similar in nature to the original Miles proposal in the Pacific Northwest, he was asked to start a regional assessment project. Eventually that project became the Southeast Climate Consortium (SECC), which was funded until 2015.

The California-Nevada RISA team began as a pilot assessment, funded through the Applied Research Center (ARC) program, based at the Scripps Institution of Oceanography at the University of California San Diego (Scripps). The impetus for the project was the 1997-98 El Niño, which OGP and the researchers at Scripps felt presented an opportunity to observe how decisions were being made in the state of California regarding climate-related impacts and use that experience to inform future work on climate services (Neirenberg 1998). That pilot eventually became the California Applications Program, then in 2010 became the California Nevada Applications Program (CNAP) when the research team expanded to include the Desert Research Institute in Nevada. CNAP was funded as a RISA until 2016.

The final project added during the pilot phase was the Western Water Assessment (WWA), based at the University of Colorado Boulder and affiliated with the NOAA Earth Systems Research Lab (ESRL). The selection of the University of Colorado was intentional, according to Nierenberg, because Hall wanted a direct link between a regional assessment and a modeling center, such as ESRL.

In 1999, proposals were solicited for a sixth region and used the program title Regional Integrated Assessments. The New England Integrated Sciences and Assessments project, based at University of New Hampshire, was funded beginning in 2001. However, that project only lasted until 2004. Harvey Hill recalled tensions between OGP's focus on climate variability as a central principle for the assessments and the project PI's greater focus on weather.

RISA Emerges as a Program

Roger Pulwarty (NOAA Earth Systems Research Laboratory) joined the staff of OGP in 1999 as the program manager for what were still pilot regional assessments. Pulwarty brought with him a background in climatology as well as hazards geography. It was during his tenure as program manager (1999-2001) that the program got its first base funding of $1 million in 2001 and gained the name RISA: Regional Integrated Sciences and Assessments. The naming of the new program was very intentional, according to Pulwarty. "Regional" was the organizing unit that fit best with decision making. "Assessments" had always been the goal of the pilot project: an iterative process of integrating interdisciplinary knowledge and experience about risks and vulnerabilities with the design and support of effective responses to those risks. And "Integrated Sciences" meant linking climate science knowledge with knowledge about social and economic activities as well as resource management and decision making processes. In an interview, Pulwarty also pointed out that the acronym created by these terms—RISA—is very close to the Spanish word for smile—*sonrisa*.

Additional RISA centers have been added every few years since the early 2000s. The Carolinas Integrated Sciences and Assessments (CISA), based at University of South Carolina, was funded in 2003. Also in 2003, the Pacific RISA, based at the East-West Center for Cultural Exchange in Honolulu, Hawai'i, was launched. In 2006, the Alaska Center for Climate Assessment and Policy (ACCAP) at the University of Alaska Fairbanks became the eighth RISA. The Southern Climate Impacts Planning Program (SCIPP) started in 2008 as a joint project of Oklahoma University and Louisiana State University. In 2010, two new RISAs were added: Consortium for Climate Risk in the Urban Northeast (CCRUN) based at Columbia University and the Great Lakes Integrated Sciences and Assessments (GLISA) at University of Michigan.

Timeline of RISA Teams

RISA Team	Years
Climate Impacts Group (CIG)	1997 - 2010
Climate Assessment for the Southwest (CLIMAS)	1998 - present
Southeast Climate Consortium (SECC)	1998 - 2015
California (Nevada) Applications Program (CNAP)	1997 - 2016
Western Water Assessment (WWA)	1999 - present
New England Integrated Sciences and Assessments	2001 - 2004
Carolinas Integrated Sciences and Assessments (CISA)	2003 - present
Pacific Regional Integrated Sciences and Assessments (Pacific RISA)	2003 - present
Alaska Center for Climate Assessment and Policy (ACCAP)	2006 - present
Southern Climate Impacts Planning Program (SCIPP)	2008 - present
Consortium for Climate Risk in the Urban Northeast (CCRUN)	2010 - present
Great Lakes Integrated Sciences and Assessments (GLISA)	2010 - present
Climate Impacts Research Consortium (CIRC)	2010 - present

CHAPTER TWO: DEFINING RISA

RISA's mission statement is to "expand and build the nation's capacity to prepare for and adapt to climate variability and change. Central to the RISA approach are commitments to process, partnership, and trust building." This broad goal is deeply embedded in the history of the program. Interviews with many of the central figures in the founding and management of the program revealed a deeply held belief in the power of knowledge about climate patterns and changes—when developed in optimal ways—to make tangible, positive impacts on the lives of people around the world.

What has emerged from interviews and the documentary history of RISA is a set of features of the RISA program, most embedded from its earliest days, which have facilitated the broader goal of producing usable science and positive impacts on people and communities (Figure 4). First, the program has created transdisciplinary space that links natural and physical scientists with social scientists and decision makers in egalitarian partnerships. Second, the program has maintained a focus on regional-scale work, which program participants believe better fits the scale of decisions and climate signals, as well as allowing for genuine partnerships to develop between scientists and stakeholders in a shared region. Third, the program began with a focus on climate variability, permitting both scientists and stakeholders to identify more tangible impacts and decisions than were available for climate change trends at the time. Fourth, a learning orientation was embedded into the program very early in its development; learning how to conduct regional assessments and act as boundary organizations is a pillar of the program. RISA program management and evaluation has often given priority to reflecting on lessons learned, sharing knowledge among RISA teams, and adapting to new circumstances. Finally, the program has often relied on innovative and flexible program management—taking advantage of opportunities as they arise to grow and shape the program.

RISA faces a number of changes to its operations. Some challenges, such as the tension between traditional academic research expectations and the needs of climate science end-users, are shared among all transdisciplinary research efforts. Others, such as climate change skepticism in the political sphere and related budget constraints, are more unique to RISA and its home agency, NOAA.

Figure 4: Conceptual model of the approaches RISA uses to achieve the goal of generating usable climate science.

Making Climate Science Usable: RISA's Mission

The genesis of RISA and the IRI, according to Mike Hall and Jim Buizer, was a trip to South America in 1986, where they explored the utility of the new Cane-Zebiak ENSO model, which had correctly predicted the 1986 El Niño. Hall and Buizer had decided to travel to the regions in South America that are most impacted by El Nino to "find out if that's even useful to humans." They traveled to Chile, Ecuador, and Brazil and met with regional stakeholders to explore whether it would be possible to make connections between seasonal climate variation, forecasting, and people's decisions about responding to climate phenomena. "What you'll see from this, I hope," said Hall, "is with Jim's impetus to help me, I was thinking about real people, solutions to real problems." Claudia Nierenberg explained the philosophy of the Office of Global Programs (OGP)[5] in the late 1980s: "We really wanted to take it to the ground and build a program that would be responsive to people's needs . . . There was a high value on whether you were building capacity." Hall summed up the OGP's commitment: "Change people's lives for the better . . . was always a motive in our office."

[5] Prior to 1990, the NOAA office hosting the precursors to RISA was Oceanic and Atmospheric Research (OAR). OAR become Office of Global Program (OGP) in 1990. The name changed again in 2005 to Climate Program Office (CPO). For consistency, I use OGP when referring to the time before 2005 and OGP/CPO after 2005.

While today a number of management agencies and academic scientists are concerned with the production of usable science, this was not necessarily the case in the early-to-mid 1980s when Hall and Buizer began to discuss the implications of the Cane-Zebiak model for decision-making. As Stokes (1997) has explored in great detail, post-World War II science was starkly divided into “basic” and “applied,” with basic research receiving a larger share of funding, attention, and prestige in the U.S. However, it may be no coincidence that the OGP staff was pushing for usable, applicable climate information while other agencies remained focused on basic research about the climate system. NOAA’s mission has always been tied to the usability of science. The three agencies that merged in 1965 to create the precursor to NOAA, the Environmental Science Services Agency (ESSA), were each concerned with the application of scientific information to human decisions. The Coast and Geodetic Survey was created to map coastlines in response to ships being lost on the Great Lakes and Atlantic coast. The National Weather Service was created to help both the shipping and agricultural sectors deal with weather conditions. The Central Radio Propagation Laboratory was focused on obtaining and disseminating information on the propagation of electromagnetic waves and their effects on radio transmission (Fleagle 1986; Hughes 1970; Shea 1987). When the ESSA became NOAA in 1970, its mission revolved around two related objectives: a) Public Safety and Welfare, including providing warnings of natural events and research on future habitability of the earth; and b) Commercial Development, including aid in the development of natural resources. Shea (1987) framed the NOAA mission as “prediction of environmental change to protect life and property, and provide industry and decision makers with a reliable base of scientific information on the world in which we live.”

In the 1970s and early 1980s, several global events also highlighted the impact of climatic events on human well-being, including the drought and famine in Ethiopia and the impacts of ENSO on Brazil in 1982-83, both of which were noted by the National Research Council (NRC 1999) as influencing the push to understand the potential benefits of seasonal climate forecasts. The combination of an agency with an applied mission, agency staff with a commitment to changing peoples’ lives for the better, and the scientific progress in seasonal forecasting came together in the mid-1980s to allow OGP staff to coalesce around the idea that better information about climate variability could be harnessed in such a way as to become usable, useful tools.

Five Features of the RISA Model

While the overarching goal of what would become the RISA program continues to revolve around making climate information useful for real-world decisions, as the program has developed and grown additional nuance and understanding has shaped the goal. Science that supports the kinds of decisions stakeholders within a given region are grappling with is the ultimate measure of success, according to several interviewees. However, they also understand that science is not the sole consideration in any decision. Another aspect discussed by interviewees of making science usable was the need to build capacity among decision makers to understand climate risks and use climate information themselves. Adam Parris (Jamaica Bay Science and Resilience Institute), a former RISA program manager, described a spectrum of ways to use information, all of which he considered as important markers of RISA success, “increased awareness of risk, ranging from identifying a need or changes in perception about a situation to actual behavior change.” In a 2000 article summarizing the early growth and development of RISA, Roger Pulwarty and Mike Hall (2000, 4) stressed “RISA projects do not advocate one set of policy options over another, but seek to evaluate the implications of different choices under varying and changing climate conditions.”

Transdisciplinarity

The concept of transdisciplinarity has generally been defined as research that includes different disciplines (interdisciplinarity) as well as the active involvement of stakeholders and/or policy makers who are affected by the research or will need to apply it to real-world problems (Hirsch Hadorn et al. 2006; Jahn, Bergmann, and Keil 2012; Mauser et al. 2013).

Early evidence of a transdisciplinary mindset (although before the term was common) in the programs leading up to RISA comes from slides created by Mike Hall in the late 1980s (Figure 5). They illustrate his desire for an evolution of the research domain from a “loading dock” model in which science is simply delivered to stakeholders (Cash, Borck, and Patt 2006) to one in which a new, shared space is created to encompass researchers, stakeholders, climate information, and non-climate factors in a comprehensive assessment process.

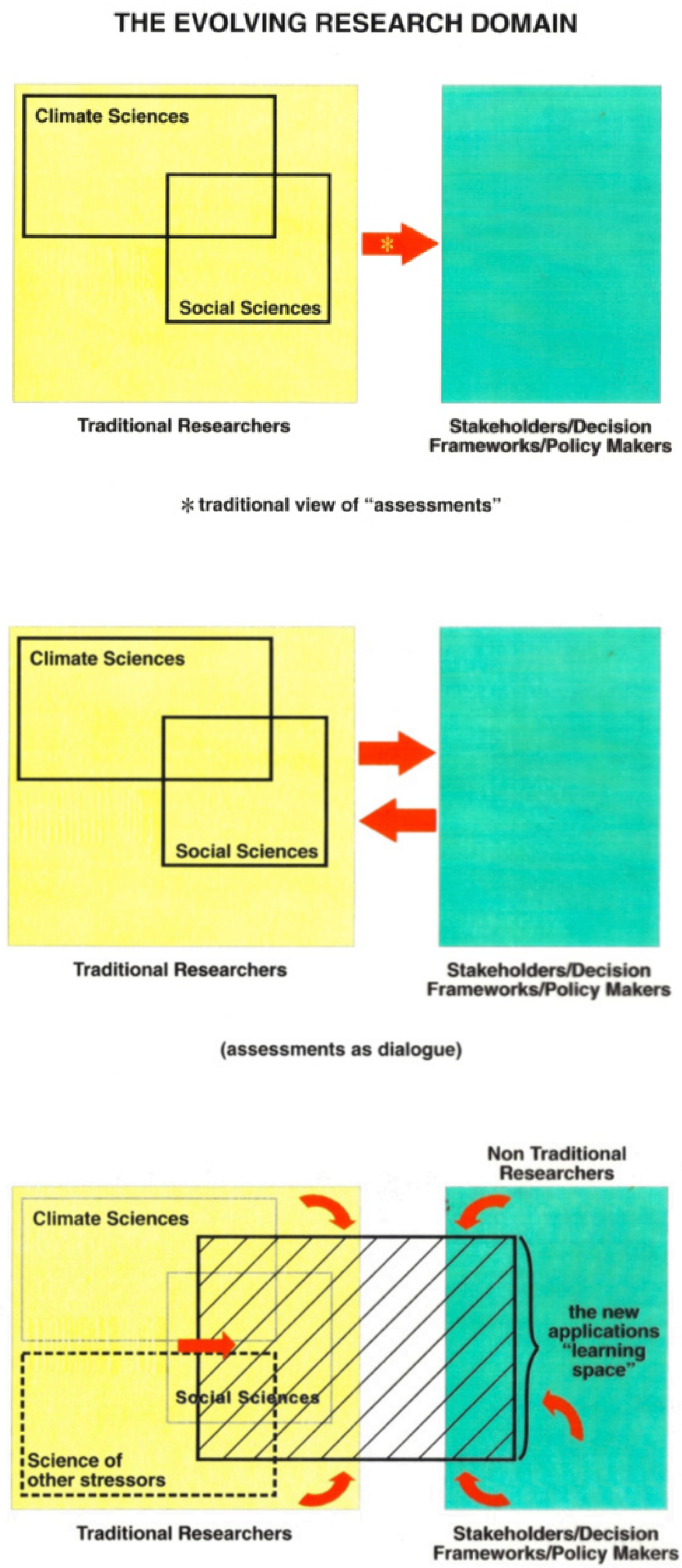

Figure 5: The evolving research domain. Courtesy of Mike Hall.

Hall was conscious of wanting to create a learning space that was not "stovepiped." He wanted to expose scientists to the users of information and "make them realize what that person cares about, how that person thinks of the problem, the mindset of that person."

Although a transdisciplinary space was always a goal within Hall's office, the idea of an interdisciplinary approach, let alone a transdisciplinary approach, often runs counter to traditional research approaches, particularly among academic researchers. Beginning in the early 1800s, universities pushed toward increasing specialization in disciplines, due to the dual pressures of industries demanding specialists (particularly during the Industrial Revolution) and the internal push to recruit students to the ranks of each individual discipline (Klein 1990). Although the pace of interdisciplinary research in academia has increased since the middle of the 20th century, those disciplinary "silos" have often remained as barriers, keeping representatives from different disciplines from sharing basic understandings of "fact" (Lach 2014) and learning each others' vocabularies, as well as encouraging competition for resources (National Research Council 2005).

Jim Buizer reflected upon the disciplinary culture of science in the mid-1980s: " Back then atmospheric and oceanic research were fighting each other. . . Pulling that community [together], let alone bringing social science too – that made it 'You guys have got to be joking!'" But, Buizer, Hall, and eventually Nierenberg put these ideas into practice through a series of workshops in South America. Buizer noted their 1989 workshop in Fortaleza, Brazil as the first time they included a social scientist:Mexican geographer Roberto Sanchez. "We were getting better and better and adding more and more [scientists] so that eventually the balance was much closer to 50-50 [social and natural scientists]," recalled Buizer. Buizer continued his explanation of the progression of their workshops, "We realized that bringing scientists into a room to talk to each other, albeit from different disciplines, was not sufficient. Then we started bringing in people that were heads of an agricultural cooperative."

An illustration of the novelty of the idea of transdisciplinary research at the time comes from Richard Moss (Pacific Northwest National Laboratory), who met Hall in the early 1990s when Moss was with the IPCC. His story illustrates that at the time many scientists simply were not thinking about the role of decision makers in the scientific process.

> Mike came in and he drew these diagrams of the research world. Then he very dramatically scrunched them together and said 'We have to break this barrier now.' People had no clue what the hell he was talking about. It was visionary. He really was.

Beyond instilling the philosophy of transdisciplinarity into the work of OGP and the early assessment projects, the staff took concrete steps to integrate multiple voices into its programs. For example, in OGP social sciences were key to building the larger learning space (i.e., conducting transdisciplinary research). As Caitlin Simpson (NOAA Climate Program Office), who became a RISA program manager in 2004, explained, it was through the social scientists that research teams could learn how to address use-inspired problems and meet climate information needs on the ground. Simpson continued, "Incorporating human dimensions work allows researchers to understand the decision context more broadly. It's been important in both understanding what stakeholders need and also really shaping the whole research agenda for the teams."

Otis Brown (North Carolina State University), chair of OGP's Global Change Advisory Committee from 1995 to 2005, also noted the central role of social science in those projects that became the RISA program. He described the early assessment project, which eventually became the RISA teams CIG and CLIMAS, as social science initiatives that were intended to provide an opening for social scientists in OGP. The inclusion of social science also helped to support one of Hall's program management goals, according to Brown: expand the scope of OGP's stakeholders to include more academics and end-users of information. Brown observed that Hall understood the need to build a constituency for OGP outside of NOAA. The early conceptual model of a climate program developed in Hall's office [discussed in Chapter 1], indicates that Hall was conscious of the need to build support from end-users and funders in order to maintain a long-term climate program.

The genesis and ultimate funding of the first RISA project proposal is illustrative of this early commitment to a larger learning space. OGP representatives were impressed with the ideas contained in the draft proposal from Ed Miles at UW but wanted additional stakeholder input. Eileen Shea recalls Hall telling Miles "You guys need to come together as a community, come together and talk about what you need." The result was a proposal that included prioritized interests and needs from a variety of resource management agencies and policy makers in the state of Washington.

Another way in which multiple voices were valued in the early evolution of RISA was reflected in its commitment to soliciting input from "outside DC." Nierenberg characterized her early years in OGP as "a time when budgets were growing so you had money to travel, to fund other people's travel so you could have participation from a wider group of people. That's a huge deal! If you can't get new people, you have the same conversation with the same people in Washington over and over again."

The idea of creating a shared, transdisciplinary learning space also is reflected in the ways in which individual RISA teams have been integrated. Under the management of Roger Pulwarty, RISA program manager from 1999-2001 (who credits Neirenberg and Hall with the idea), the individual RISA teams were linked together in such a way as to promote learning within the organization. Shea describes the process: [Pulwarty] saw the capacity for building something that was stronger if those patchwork pieces [individual programs] were woven together into a quilt." Harvey Hill, RISA coordinator from 2001 to 2004, used a different metaphor to describe what happened when the teams began to cooperate and communicate, "they began to be like an arrayed telescope . . . like an arrayed set of mirrors to make a better telescope."

CHANGING THE CULTURE OF SCIENCE

One marker of success in creating a truly integrated, transdisciplinary learning space, according to several interviewees, is changing the ways in which scientists work to help them learn to increase the impact of their research by engaging with the people who will use it. Several interviewees could point to specific examples of scientists coming away from interactions with stakeholders feeling utterly changed. "I came home, I was a different person. More importantly, I was a different scientist. It changed my life," Hall recalls a climate scientist telling him after one of the early El Niño workshops in South America. Hall continued, "That's what we were trying to do . . . Now multiply that by at least a few hundred if not a few thousand and you have some of the early promise of an activity like the RISAs." Parris, reflecting on his time with the RISA program, noted that an ongoing goal is to "build the capacity within the scientific community to do science in a different way."

An important aspect of changing the way that science is done is influencing the way that new scientists are trained. Shea stressed that a key to success in RISA (or other transdisciplinary endeavors) is investing in students and building a cadre of new scientists. Parris went so far as to suggest that a performance metric for RISA could be the number of careers jump-started by the program. Two scientists who started their careers at CIG recalled the learning space created there as "exciting, it gave them [principal investigators] opportunities to see things, new problems . . . and new tools. I think the same for those of us that came to work here as post docs or staff. It was an exciting place to be, with new knowledge that's relevant and applied," reflected Amy Snover. Nate Mantua (who was a postdoctoral researcher with CIG beginning in 1995) explained that his experience with CIG "was great preparation for the job I have now [which involves managing both federal and university scientists] working on fish habitat and climate, land use, water use, and human behavior. I'd say that my preparation and experience at UW was extremely important for me to get this job and be successful at it."

At least four scientists who started their careers within RISA have become principal investigators (PIs) in RISA teams. Victoria Keener did her Ph.D. work with SECC and is now PI of the Pacific RISA. Phil Mote was a postdoctoral researcher with CIG and is now PI of CIRC. Dan Ferguson started as a program manager with CLIMAS, then became director of CLIMAS and is now its PI. Maria Carmen Lemos was a post-doctoral researcher with CLIMAS and is now PI of GLISA.

Regional Focus

A focus on regional-scale research has been integral to the RISA program and, more broadly, to the development of usable climate science. Prior to the start of RISA, the climate science community was already grappling with the need to make its science relevant through regional-scale analysis. Writing in 1988, Kellogg explained the problem with global-scale information about climate change:

> It is not enough to tell them [decision makers] that the world will be warmer, when what they need to know is the kind of changes to be expected here—wherever "*here*" turns out to be. And it is the changes in rainfall, temperature, and soil moisture on a regional scale that determine where certain things can grow and where agriculture and forestry and tourism will flourish or fail (Kellogg 1988, 27).

Ten years later, the National Research Council (NRC) made a similar observation in *Making Climate Forecasts Matter*, the report commissioned by OGP. They explained that seasonal climate forecasts are most useful when available at a scale sufficient to capture regional dynamics, which they note is not always the case (National Research Council 1999).

In addition to the importance of providing, as Kellogg explained, information about "*here*," making information useful and usable requires understanding a region's capacity, vulnerabilities, and goals in responding to climate impacts, all of which require direct engagement with decision makers. Regional-scale projects supported the goal of producing usable science because they allowed for this greater interaction between scientists and stakeholders and the scaling of scientific information to one at which decisions are commonly made (Pulwarty and Hall 2000). Eileen Shea explained that "working at the regional level was absolutely essential and it was very different than what you could conceive if you were working out of a DC office." She identified "establishing relationships with key decision makers in each region" as a marker of success for the RISA program. Similarly, Pulwarty and Hall (2000) listed as a marker of success the vision of a RISA team that "works and is managed as the same local- to regional-scales of decision making."

An example of this process came from the early CIG project, described in Chapter 1, in which the research team analyzed projected changes in streamflow at a single central stream gauge in the region. The analysis was deemed "interesting but useless" by water managers, according to CIG staff, because each manager required information about streamflow in specific sub-basins to adequately inform decisions. In response to this feedback, the CIG team revised the analysis to include the relevant sub-basins and eventually developed projections for more than 300 stream gauges in the region (Snover, Hamlet, and Lettenmaier 2003).

An additional benefit to regionally focused work, noted by Buizer, was that it allowed scientists to engage in an area they cared about. He cited his own connection to the Pacific Northwest as a reason he was excited about supporting the original Miles proposal. And he noted that one reason for the success of the Pacific RISA was Eileen Shea's love of the region. "These things [transdisciplinary projects] are so hard so you have to really love it." And, he continued, by launching programs with people already grounded in the different regions, "we didn't have to start in places with zero trust." In order words, by encouraging people to work in regions where they had connections, the program also benefited because they could see progress and impacts sooner than had the research team started without local connections.

Climate Variability Focus

Particularly in the start-up phase of RISA, a focus on climate variability provided the teams with a platform on which to build the new program. Climate variability, as opposed to climate change, provided more credible science (at the time), opportunities to work through the assessment process using existing variability as an analog for climate change adaptation actions, and a way to connect with stakeholders who may have been (and continue to be, in some cases) skeptical about climate change.

While we now know that climate change has been impacting the earth for decades, information about the rate and amplitude of change was not sufficiently credible in the mid to late 1980s to give stakeholders grounded, tangible information about long-term trends at a scale commensurate with their decision-making. However, past variability can provide a proxy to understand capacities for adaptation to future climate change—a point made by Mickey Glantz (1988), a member of OGP's Global Change Advisory Committee. In the words of Buizer, the early focus on El Niño meant they were starting with "something" rather than being "totally theoretical."

The focus on variability gave the research teams opportunities to work through the process of assessment, using examples from the impacts of variability. The teams could work to understand impacts and responses to known phenomena, the best processes for undertaking these assessments, and then apply the best practices to the assessment of a less-tangible phenomenon: climate change. Climate variability, as a natural phenomenon, has been affecting people and communities since time immemorial. Whether or not there were specific names for the effects of periodic climatic shifts, people are familiar with the concept that there are periods of drought, heavy rains, cool summers, or relatively warm winters. Being able to provide information about drivers of these changes—and predictions of when they might next occur—gave RISA researchers tangible information to communicate to stakeholders. And stakeholders could communicate to researchers how they have adapted to different conditions in the past.

Finally, the focus on climate variability allowed RISA teams to establish partnerships in their regions with decision makers who otherwise may not have been open to the message about climate change. Focusing on natural climate variability, such as droughts or extreme precipitation, allowed the researchers to depoliticize their discussions and build new relationships with climate information users without immediately confronting what is still, unfortunately, a highly fraught issue. The focus on variability in the original CIG proposal, while not Ed Miles's first choice, did allow it to be funded while avoiding the "political hot potato" of climate change (N. Mantua). Barbara Morehouse (retired from University of Arizona), former program manager of CLIMAS, said the way she built bridges to the water management community in Arizona was by discussing ENSO with them, building trust, then slowly introducing the concept of climate change. Morehouse noted that her acceptance by water managers also hinged on a strong partner in the management community—Kathy Jacobs—who was then the longtime head of the Tucson Active Management Area (one of five groundwater management areas defined by the state of Arizona as requiring specific management practices to protect groundwater resources) and went on to lead the Third National Climate Assessment.

One of the significant undertakings of OGP that explicitly linked climate variability to the broad goals of making climate science useful was the 1999 NRC report, *Making Climate Forecasts Matter*. OGP asked the NRC Committee on the Human Dimensions of Global Change to undertake the report with the specific task: "to provide scientific input to NOAA on research needs and programs in the area of human dimensions of seasonal-to-interannual climate variability, including issues of societal vulnerability, use of forecast information, the value of short-term climate prediction, and adaptation to climate variability with and without climate forecast information (National Research Council 1999, preface X)."

The NRC panel identified three key factors in making climate forecasts usable for decision makers. First, research to improve climate forecasts doesn't necessarily make that research useful to those whom climate affects, but forecast utility can be improved by consciously linking climate research to users' needs. Second, the effectiveness of forecasts for supporting decision making depends on the ways in which information is communicated to recipients, such as taking into account their coping strategies, cultural traits, and specific situation. The panel noted that participatory strategies are likely to be most useful in these efforts. Third, both climate impacts and use of climate forecasts have consequences for people and communities, often due to social, environmental, and economic forces having nothing to do with climate variability; researchers must be sensitive to the potentially differential impacts of climate events and information. The report reinforced the value of many of the principles already in play in the nascent RISA program, such as the necessity of creating direct links between researchers and users as well as encouraging the kind of experiments in climate information delivery that still defines the program.

Learning Orientation

When discussing RISA goals and program function, interviewees commonly characterized RISAs as "experiments" in how to undertake integrated assessments, create boundary organizations, and deliver climate services. Pulwarty et al. (2009) formally defined RISAs as "experiments in the design and implementation of climate and environmental services." Another framing came from Eileen Shea, who noted that "process is as important as product" in the network. Three examples of how the network has integrated learning into its day-to-day functions are the general openness to experimenting with new ideas, the integration of both formal and informal evaluation of those experiments into project and program functions, and the institutionalization of efforts to infuse the network with new ideas on a regular basis.

This commitment to experimental and adaptive programs is evident in the earliest days of OGP and the regional assessment pilots. Nierenberg and Buizer both recall OGP as a workplace that encouraged experimentation and innovation. To demonstrate the culture of the office at the time, Buizer related a story about his first performance review with Hall in which he recalls Hall asking "How many [mistakes] did you make this year? If you didn't make any [mistakes], you aren't taking enough risks."[6] Buizer continued, "We were lucky we were in an office where we had the freedom to take a risk and 'screw it' if it didn't work." Although both Ed Miles and Mike Hall seem to have given each other credit for the phrase, both are remembered for framing the process of these new kinds of regional assessments as "a voyage of discovery" (Parris and Garfin 2016).

From the start, RISA participants were encouraged to question their own work and change practices in light of new information. As mentioned previously, the original vision for the institute came from a conversation between Hall and Buizer in 1986 in which they sketched out the concept of a centralized research entity that would distribute climate information to a variety of regionally based programs around the world in areas often hard-hit by impacts from El Niño. Buizer cited several specific lessons the OGP staff took from their international experience and applied to setting up the IRI. They focused first on variability because it was more certain information at the time. They assessed and addressed the information needs of on-the-ground decision makers. And they flipped the original IRI model, making RISA a decentralized program in which each regional center had enormous autonomy to engage with and learn from local decision makers and stakeholders.

Formal internal learning processes, such as through program evaluation, have also been part of RISA since the program was formalized in 2000 (Pulwarty and Hall 2000). Early evaluation metrics included:

- Effectiveness of knowledge integration (i.e. co-production of the knowledge by both researchers and stakeholders);
- Appropriateness of methods and scales for linking physical and social factors as well as integration of temporal scales;
- Existence and use of criteria for self-evaluation within teams;
- Public awareness through media and education activities;
- Mechanisms for providing and evaluating "services" and information transfer back to NOAA and other agencies for improving operational and strategic research activities; and
- Continued evaluation of the University-federal partnership in meeting the needs of the program (and its constituents).

Evaluation of both processes and outcomes continues to play a major role in RISA activities. For example, the Pacific RISA uses an evaluative framework in which they track how many partnerships and collaborations they have established in order to gauge the reach of their program and identify gaps in their coverage. They also track the quality of those relationships, through qualitative descriptions of stakeholder roles and involvement, in order to identify best practices in building collaborative partnerships and ensure that the practices are employed consistently in the organization (Ferguson, Finucane, et al. 2016).

Mike Hall set the expectation that new ideas and perspectives would continually infuse the office and the network. He used OGP's external advisory committee, the Global Change Advisory Committee, as reviewers and sounding boards for all projects within OGP. Each year, program managers presented their activities and progress to the committee, in a process one program manager described as "defending a dissertation every year!". Otis Brown described the review process:

> [The reviews] meant for Hall, and for the program managers, you had to have an openness to external critiques, because you were going to get it whether you wanted it or not. This committee was going to tell you what they thought, and some of them were not pleasant, because it was clear things were not working right, or it was clear that some part of a program was not being very productive, and people were not shy about saying [it].

When Caitlin Simpson joined the office, she saw the experimental orientation in action, "Starting at the beginning of RISA, Mike, Jim, and Eileen had the perspective that you should be collaborative with the external community . . . and you should design the program to be flexible enough to allow them to come up with ideas, propose ideas, meet the needs they saw in the region."

Innovative Program Management

Several interviewees discussed RISA program management as "different" from standard research program management. Descriptions of the innovative management fell into two broad categories: management within the OGP/CPO office and the ways in which that organizational framework was expressed in management of the individual RISA projects in the regions. Within OGP, Hall's ability to manage bureaucratic structures, while still supporting innovation, was commonly praised by interviewees. A focus on building coalitions and support systems around programs was another theme often discussed. Several network members praised the manner in which the regional teams are managed by OGP, which allows for significant regional customization.

As discussed above, the OGP office under the leadership of Mike Hall was a place that encouraged innovation and experimentation. Hall's knowledge of bureaucracy was cited by many of the early RISA participants I interviewed as a key factor in creating the program: he knew how to get new ideas moving and funded in the system. Otis Brown recalled Hall explaining that there is a four-year window in any organization in which to launch and stabilize a new program or idea.

[6] Quote has been edited to remove profanity.

He was a student, a good student of how bureaucracy worked, and so he knew that he had this window to do this, to develop a budget, a constituency, a program, etc. And after that it was going to be a real fight, because the bureaucracy wants to return to the status quo, and he had to be part of the status quo at that point.

Another hallmark of Hall's management philosophy was his cultivation of coalitions surrounding his programs. This started as early as TOGA, which had an advisory panel that, according to Hall, helped create a long-term vision and broader support for the program. Ed Sarachik (University of Washington Climate Impacts Group), one of the original principal investigatorss in CIG, described Hall's management abilities:

He was so far ahead, he understood organization, he understood how to get things done in a bureaucracy, he understood the value of an advisory committee, he understood the value of a meeting, what you have to take into a meeting, what you have to bring out of a meeting. I urged him to write *The Bureaucrat's Manual*, in the best sense.

A particularly innovative management tactic remarked upon by Brown, as well as Buizer and Hall, was Hall's allocation of at least 50 percent of OGP's budget to competitive awards, as opposed to allocating it entirely for internal programs. This approach furthered several program development goals, including infusing the program with university-based innovations, diversifying the research approaches, expanding national and international partnerships, providing an "applied" complement to the kinds of work NSF was funding, and—importantly for program development—broadening the constituency who was likely to support OGP's budget requests. Looking back on Hall's early climate observation network diagram, we can see the use of his budget to further the goal of stabilizing the system through building a broader stakeholder base.

The philosophy of experimentation appears to have played out in the way in which individual RISA teams were managed by OGP/CPO. In keeping with the creation of RISAs as experiments in climate services, many participants felt that they had been given great latitude to explore how best to meet the needs of stakeholders without too much control from OGP/CPO. Amy Snover discussed this freedom in the early years of CIG, "There was this real recognition that climate impacts are different everywhere . . . it makes sense for there to be some experimentation in how you connect people . . ." Dan Ferguson (University of Arizona Institute of the Environment) and Gregg Garfin (University of Arizona Institute of the Environment) (both have managed the CLIMAS team) described the way in which CPO has encouraged the growth of certain veins of research through incentives—not directives. Ferguson explained, "I think at some point they learned that the strength of what they had in hand was funding and letting this regional expertise [take over]."

An example of how OGP facilitated regional control of the science and partnerships can be seen in a 2001 a report to OGP's Global Change Advisory Panel. The report outlined the need for a three-phase process of regional team growth (Pulwarty 2001). During Years 1 and 2, each team was largely to focus on team building, characterizing its respective region of interest, and identifying key issues in the region. Years 2 and 3 were to involve refining preliminary studies, clarifying issues, and developing criteria for program evaluation. In Year 4 the program was expected to expand to include new research and new partners. The substantial front-end time available to the regional teams to build partnerships and assess regional science needs reduced the expectation that new teams would come in with a pre-determined set of research questions; teams were encouraged to treat needs assessment and team building as an integral part of the process of delivering climate information.

In her guidance to decision makers involved in developing a national climate service (which has never materialized), McNie (2008) summarized some of the management practices that she considered successful in the RISA network and that could be replicated in the proposed new climate service. "Successful management of a climate services organization," she wrote, "requires decentralized management methods and a 'hands-off' approach" (McNie 2008, 238-239). McNie acknowledged that letting go of management models built around national headquarters, standard approaches, and fixed hierarchies may be challenging for some federal employees accustomed to the more predictable model. However, she recommended that the agencies "provide adequate resources for the regional centers and then get out of their way."

Challenges of the RISA Model

Despite the many successes and longevity of the RISA network, there are challenges facing the network and the field of climate services in general. Interviewees identified five broad challenges the RISA program faces. First, the tension between the expectations of academic research and applied or user-driven research has been a concern for RISA team members since its earliest days. A second challenge for the program has been the tension between conducting research on both climate science and the process of delivering climate services while also being pushed by stakeholders to be an operational climate service organization. A third challenge, common to many applied research organizations, is that linking research findings to decision making is not a straightforward process; many applied researchers have described the difficulties of navigating complex decision frameworks even when highly salient and credible information is available. A fourth challenge relates to the political climate surrounding the issue of climate change and support for climate research (and other scientific research). Finally, although often hailed as innovative, interviewees also identified challenges in the program structure and with the role of RISA inside a much larger agency (NOAA).

As was noted by many interviewees, people working in academic institutions must often balance the kind and amount of research and publications that are traditionally demanded of academic researchers against the demands of transdisciplinary work, which involves establishing relationships with stakeholders over long periods of time before demonstrating research impacts (see for example, Bell, Shaw, and Boaz 2011; Roux et al. 2010). Barbara Morehouse discussed the “independent streak” among PIs, which at times made it difficult to focus on applied, stakeholder-driven questions. Morehouse’s observations are similar to those of current CLIMAS director Dan Ferguson, who noted that the expectations for RISA researchers are that they produce the same quality of research as other “basic” researchers, but within a different research framework. Amy Snover, with CIG, described this challenge as “all the hurdles to . . . interdisciplinary, applied research in the academic world.” She also pointed to the broader challenge of conducting interdisciplinary work regardless of setting, and “learning to speak each others’ language, to functionally collaborate,” a point echoed by Pulwarty and colleagues (2009) and the NRC (National Research Council 2015, 2005).

These tensions between academic expectations and capacities and the desire to conduct transdisciplinary research with real-world impacts were identified as long ago as the 2000 RISA program meeting. Comments from meeting participants complained, “No extra credit is given for doing RISA-type work with users” and “Often users want ‘one-stop’ shopping, which must be interdisciplinary, but is not always possible given university structures.” Despite the opportunity to be trained differently, several RISA alumni have struggled to fit into traditional academic positions or have failed to obtain tenure-track positions and the job security that brings (see for example, Brugger, Meadow, and Horangic 2015).

There are also tensions between producing research versus producing operational tools or information. Pulwarty and colleagues (2009) described RISA as an experiment in how to provide climate services, but stressed that the program was not intended to become operational climate service providers. The authors also noted the lack of university capacity to support both start-ups and long-term programs. Moran et al. (2009) and Meadow et al. (2016) similarly noted that modern universities are often ill-equipped to sustain long-term programs, given their increased reliance on external, project-based funding. As far back as the 2000 program meeting, questions were raised about whether RISA should act in a consultancy framework and charge for labor and information costs. Demand for climate information is increasing as more resource managers and policy makers grapple with how to adapt to climate change impacts (McNie 2007; Lacey et al. 2015). The constraints of operating as experimental programs within institutions ill-equipped for operational work have been noted by RISA network members as a long-term challenge for the network.

Another broad challenge of transdisciplinary work that affects RISA and similar programs is that integrating science into decision making is not a straightforward process. It is difficult to both achieve results (such as producing the science that meets the exacting requirement of a decision maker juggling multiple priorities and groups of stakeholders) and demonstrate impacts from the science (such as drawing a clear link from a piece of information to a policy or decision and on to an action). There is a large body of literature that addresses these challenges and it is not within the scope of this work to cover the entirety of that work. However, a brief summary of the issues follows.

Decision makers, whether organizations or individuals, tend to seek information when they have a problem to solve or a gap in their knowledge to fill. If stakeholder agencies have not identified that gap or a specific use for the information, new information is less likely to be used (Choo 2006). Organizations are also more likely to trust and use information that comes from within the organization, as opposed to information coming from an external source (Rich and Oh 2000; van de Vall and Bolas 1982). When a decision maker encounters new information, she or he may take time to move along a spectrum from conceptual use (such as feeling better-informed about a topic) to instrumental use (actual application of the information to a decision) (Oh 1996). And decision makers must balance far more lines of knowledge than just science when making decisions that will impact socio-ecological and political systems (Cvitanovic et al. 2014). These challenges are not complete barriers, there are ways around each one. RISA was designed as an experimental program intended to develop ways to address and overcome these very challenges. While the program has made significant process and can point to several specific examples where it has successfully facilitated the integration of climate science into policy decisions (Parris et al. 2012; Ferguson, Finucane, et al. 2016), the depth of research exploring the challenges of integrating science and decision making illustrates that there is a long road ahead.

The broader political climate also poses certain challenges for the RISA network, according to interviewees. As the network has moved into the climate change field due to stakeholder demand, it has also entered a more politically charged arena. Several interviewees noted that “climate skepticism” in the U.S. in general and hostility to climate science and social science in the U.S. Congress are both threats to the future of the program.

Ironically, despite this climate skepticism, several new federal and state climate service organizations have been created in recent years. While the new organizations are helping to meet the demand from stakeholders for climate services, they have created some confusion among legislators about each organization’s roles and responsibilities. “Even though . . . we know it’s important for there to be some degree of overlap [among the various organizations] that doesn’t play well. That’s seen as waste [by certain legislators].”

A re-examination of Glantz’s list of “Constraints on Action to Combat a Global Warming” (Glantz 1988, 50-60) provides additional context for the challenges facing the program. Glantz’s role in RISA, through his pioneering work on climate impacts and his seat on the OGP advisory committee, give additional weight to the challenges he identified regarding planning for, adapting to, and mitigating the effects of climate change. The enormity, time scale, and uncertainties inherent in climate change make any efforts to address its progression and impacts challenging for resource managers, decision makers, and scientists alike. Glantz specifically highlighted the following constraints:

- Issue competition—decision makers deal with a range of issues competing for time, attention, and funds at any given moment.
- Conflicting time horizons—the long-term nature of many environmental problems does not mesh with many social, economic, and political decision horizons.
- Discounting the future—the tendency for the current generation to more highly value their own well-being than that of future generations.
- Discounting the past—the tendency to discount the importance of value of past experience, particularly with past climatic variability.
- Scientific uncertainties—scientific uncertainties can make decision making riskier (or perceived as riskier).
- Problems with alternative energy sources—conflicting views of which (or whether) alternative energy sources are optimal.
- Societal cleavages—different regions are impacted differently by climate change and actions to limit climate change.
- Population increase—global populations are growing and as developing nations improve their economies they tend to use more fossil fuels; both trends increase the rate of climate change.
- Warming-as-process versus warming-as-event—those who view warming as an event may wait until they see evidence of change before taking action.
- Diffuse impacts—regional and local impacts have not been identified.
- Lack of dread factor—the relative slow rate of change has not translated into dread for many people.
- Technological fix—some people retain a belief that a technological fix is possible.

While many of these constraints have changed since 1988 when Glantz compiled them, a surprising number, such as scientific uncertainty, societal cleavages, and issue competition, remain barriers to integrating climate information into decision making today.

Scaling down from broader societal challenges, interviewees also identified some challenges within the program structure that may affect the ultimate success of the program. On one hand, the experimental approach of RISA has allowed individual projects to address regional issues in unique ways. However, Pulwarty et al. (2009) noted that the individual development of each RISA team has contributed to a lack of specificity in goals across the program as whole. It can be hard to summarize the priorities and successes of RISA, given that there are at least 10[7] possible answers to those questions. The diffuse network also means there are inconsistencies between the teams. Some stress social science more than others, some focus on narrower climate questions than others. Interviewees did not see an inherent weakness in the different approaches (as is clear from the discussion above, the diversity is generally viewed as a strength), but painting a clear picture of the program as a whole is made more challenging by the variety of approaches represented.

Finally, there are challenges linked to RISA's placement within a large federal agency and its ability to attract attention and resources. Despite their respect for the CPO staff, several interviewees were frustrated with its ability to keep pace with the development and expansion of individual RISAs, given CPO's shrinking budget and staff. Looking back to the original DeReget model of a climate-observing system (Figure 1), DeReget emphasized the importance of having the backing of social, economic, and political systems to ensure its success. But the development of a core constituency for the program may be hindered by the diffuse nature of the RISA teams, each with their own priorities and stakeholders. Their individual successes cannot so easily be communicated to funders and other potential constituents.

The structure of RISA's parent agency, NOAA, may also present challenges for this small, relatively low-profile program. Fleagle (1986) noted that NOAA's constituency is fragmented among oceanographers, meteorologists, fisheries scientists, and marine engineers. Perhaps with so many competing priorities, it is a challenge to find a consistently supportive champion within the host agency for a program without flashy equipment or whose work is as immediate applicable as the National Weather Service.

Conclusions

Over the course of 18 months, I had opportunities to talk with 18 current and past members of the RISA network (some multiple times) as well as reviewing hundreds of documents—published and unpublished—that shed light on the development and function of RISA. I have tried to accurately reflect the experiences of those people who helped launch—and continue to manage—this extraordinary program.

The ways in which RISA network members define their program are remarkably consistent despite a span of over 20 years of experience represented by the interviewees. The goal of RISA is clear to its network members: make climate science useful and usable and have a positive effect on the world, particularly on those most vulnerable to the impacts of climate variability and change. According to interviewees, the program that developed to address this goal did so and distinguished itself by using five approaches: 1) creating transdisciplinary spaces through its research and management approaches; 2) focusing on regional-

[7] There have been as many as 11 RISA teams at one time. At the time of writing, 10 teams were funded.

scale science, regional decisions, and regional relationships; 3) using climate variability information as a scaffold to understand regional impacts, responses, and information needs, then using those examples to address impacts from climate change; 4) maintaining a learning orientation within the program by integrating evaluation and reflection into program management; and 5) using innovative program management strategies that suit an innovative research program. These approaches have evolved, as would be expected, over the last several decades. For example, several RISA teams now regularly work at sub-regional scales with urban planners or other municipal-scale decision makers. Exploring how that evolution occurred and the extent to which the founding principles still drive day-to-day decisions is beyond the scope of this report, but could be discussed in another phase of research.

The interviewees' perceptions of challenges for RISA were somewhat more diffuse, perhaps as a result of length of the time span covered. Some interviewees reflected upon challenges in the initial start-up phase and some were dealing with challenges in the current program. However, one overarching theme was the struggle to balance the output demands of academic science with the process demands of transdisciplinary research. While not unique to RISA, the network members, with their 20-plus years of experience, are certainly in a better position than most to appreciate this challenge. Another challenge discussed widely included the tension between RISA's role as a set of experiments in delivering climate services and the demand from stakeholders for operational entities.

A remarkable feature of RISA is that, despite the challenges facing the program, it has become and enduring network of people focused on providing useful, usable science to the public. Staff and researchers often stay with the teams for years. As discussed above, some of them progress through multiple career stages within a single RISA team. People I was able to interview spoke highly of the program as a whole and fondly of their time within it. I was continually struck by interviewees' thoughtfulness about and dedication to the idea that, through promoting a process of collaboration and cooperation between science and society, they could make a positive impact on the world.

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LIST OF ACRONYMS

ACCAP	Alaska Center for Climate Assessment and Policy
ARC	Applied Research Center program (of Scripps Institution of Oceanography)
CAP	California Applications Program
CCRUN	Consortium for Climate Risk in the Urban Northeast
CIG	Climate Impacts Group
CIRC	Climate Impacts Research Consortium (at Oregon State University)
CISA	Carolinas Integrated Sciences and Assessments
CLIMAS	Climate Assessment of the Southwest
CNAP	California Nevada Applications Program
CPO	Climate Program Office
DOE	U.S. Dept. of Energy
ENSO	El Niño-Southern Oscillation
EPA	U.S. Environmental Protection Agency
ESRL	Earth Systems Research Lab (of NOAA)
ESSA	Environmental Science Services Agency (the precursor to NOAA)
GARP	Global Atmospheric Research Program (of NOAA)
GFDL	Geophysical Fluid Dynamics Laboratory (of NOAA, based in Princeton, NJ)
GLISA	Great Lakes Sciences and Assessments
IPCC	Intergovernmental Panel on Climate Change
IRI	International Research Institute for Climate and Society
IRICP	International Research Institute for Climate Predication
JISAO	Joint Institute for the Study of Atmosphere and Oceans (a collaboration of the University of Washington and NOAA, based in Seattle)
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NSF	National Science Foundation
OAR	Oceanic and Atmospheric Research program (of NOAA; was renamed Office of Global Programs)
OGP	Office of Global Programs (of NOAA)
OMB	U.S. Office of Management and Budget
OTA	Office of Technology Assessment
PDO	Pacific Decadal Oscillation
PMEL	Pacific Marine Environmental Laboratory (of NOAA)
PNNL	Pacific Northwest National Laboratory
RISA	Regional Integrated Sciences and Assessments program of NOAA
SCIPP	Southern Climate Impacts Planning Program
SECC	Southeast Climate Consortium
TOGA	Tropical Ocean Global Atmosphere program (of the World Climate Programme)
USGCRP	U.S. Global Change Research Program
WWA	Western Water Assessment (a RISA)