RISA 2020

A RISA community vision for future Regional Integrated Sciences and Assessments (RISA) efforts to match advances in climate impacts science with the needs of resource managers and planners

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Disclaimer: This document reflects the thoughts of individuals involved in the RISA program but not necessarily those of the institutions of which they are a part.

RISA 2020

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Abstract: The societal challenges associated with climate change and variability are vast and growing and expressed in unique ways in a variety of sectors and regions. The National Oceanic and Atmospheric Administration's (NOAA) Regional Integrated Sciences and Assessments (RISA) program was created in 1995 to pioneer innovative mechanisms for enhancing the value of climate information and products for understanding and responding to these challenges at the regional scale. In this white paper, the past, present, and future of the RISA program are explored, focusing on the relevance of the evolving "RISA model" of stakeholder-inspired research and activities for future relationships between RISA, NOAA, and the anticipated National Climate Service (NCS). The insights emerging from discussions among members of RISA teams in the regions and RISA management at NOAA support the primary contribution of the paper: a vision of what the RISA program should look like in the year 2020.

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Executive Summary

The NOAA Regional Integrated Sciences and Assessments (RISA) program pioneers innovative mechanisms for helping stakeholders understand and respond to a variety of challenges associated with climate variability and change. As of January 2009, there are nine region-specific RISA teams (listed alphabetically in the text box, see map on p. 9).

Working in sustained partnerships with local decision-makers, these RISA teams are not only instrumental in helping stakeholders understand and adapt to regional climate impacts, but are gaining valuable insights into what is required to bridge the gap between research and applications. These lessons are particularly salient as efforts to design a National Climate Service (NCS) move forward.

At the core of the RISA philosophy is the observation that climate variability and change are global phenomena, but impacts are primarily manifest at regional scales in environmental and social issues such as those related to changing hydrologic cycles, increasing vulnerability to natural hazards, agricultural disruptions, environmental disturbances, and sea-level rise. Often, these climate challenges combine with and exacerbate other stressors, such as population growth, energy development, and transitions in local economies.

The imperative to adapt to these complex challenges often falls upon local decision makers who need assistance understanding climate trends, anticipating impacts, and formulating adaptation strategies. This requires sophisticated information and information delivery techniques integrating state-of-the-art earth and atmospheric science with applied hazards assessments, economic impacts studies, institutional assessments, resource management analysis, and other social and natural sciences.

Current RISA Teams

Alaska Center for Climate Assessment and Policy (ACCAP) (Alaska and the U.S. Arctic)

California Applications Program (CAP) (California and Nevada)

Carolinas Integrated Sciences and Assessments (CISA) (North and South Carolina)

Climate Assessment for the South West (CLIMAS) (Arizona and New Mexico)

Climate Impacts Group (CIG) (Washington, Oregon and Idaho)

Pacific RISA (Hawaii, Republic of the Marshall Islands, Commonwealth of the Northern Mariana Islands, Guam, Federated States of Micronesia, American Samoa, Republic of Palau)

Southern Climate Impacts Planning Program (SCIPP) (Arkansas, Louisiana, Mississippi, Oklahoma, Tennessee and Texas)

Southeast Climate Consortium (SECC) (Florida, Alabama and Georgia)

Western Water Assessment (WWA) (Colorado, Utah and Wyoming)

For over a decade, the RISA teams have been at the forefront of this work, creating regionally-specific climate impacts assessments, forecast products, and decision-support tools. This work is both shaped and strengthened by the long-term relationships RISAs have developed with decision makers and stakeholders at multiple levels of government and the private sector. The RISA efforts also often benefit from as well as contribute to those of complementary regional and local climate programs, such as the Regional Climate Centers (RCCs), State Climatologists (SCs), the National Weather Service (NWS), and

other federal agency efforts. In several cases, RISA teams include SCs, members of RCCs, and federal agency researchers from NOAA and other federal entities.

The types of products and management efforts undertaken by the RISAs vary widely, but share the common feature of emerging from real-world challenges faced by stakeholders. Many RISA efforts were prompted, at least in part, by severe climate events in the Northwest, Southwest and Southeast, and by a growing understanding of the linkages between regional impacts and larger-scale climate phenomena, particularly the El Niño/Sothern Oscillation. The work on climate variability continues, but is increasingly joined by efforts focused on climate change. Coincident with this expansion, RISA teams are increasingly asked to serve a broader network of users, adding state and local legislative, policy, and planning entities to the existing base of operational constituencies, as well as responding to steady growth in information demands from the general public and the media.

Lessons from the RISA Experience

The RISA experience provides valuable "lessons learned" that have direct relevance to regional and national climate services:

- *Building trust requires a sustained effort*. Effectively engaging decision makers requires sustained, iterative, and consistent contact.
- *Integrated and interdisciplinary climate information and research is required*. Answering the real world questions raised by regional stakeholders about climate impacts requires integrated observations, forecasts, projections, research, assessment, data management, and outreach across varying time and space scales.
- *Information must be contextual and relevant.* Products must be relevant to the timing and spatial scale of decision making. Additionally, the role of institutional constraints, laws, and organizational structure in affecting the use of climate information must be known.
- *Proactive engagement is required.* Cultivating the audience for climate knowledge and building the capacity for climate decision support and forecast use requires proactive communication with all levels of an organization and the stakeholder community.
- *A dynamic and flexible organization is required*. Climate service providers must track salient issues, keep abreast of cutting-edge science, build capacity by engaging top experts, and expand relevance to meet changing climates, societal needs, and technologies.

Perhaps the most salient lesson emerging from the collective RISA team experience is that the societal demand for climate services is expanding rapidly. While the RISA teams are often able to meet these growing demands (at least in part), the RISA program is not designed as an operational climate service—the teams have neither the geographic coverage nor the resources to play that role—but is rather a vehicle for pioneering the strategies and mechanisms that will be necessary as NOAA and its partners ultimately undertake this role. A number of those partners – Regional Climate Centers, State Climatologists, National Weather Service – reach a broad range of stakeholders as well as provide critical climate monitoring and research activities to the RISAs, the larger climate community, and the public.

The "RISA model" of climate services that has emerged relies heavily on participatory approaches featuring two-way dialogues between researchers and user groups, uses iterative and sustained relationships to build mutual understanding and trust, and is implemented through collaborative, multi-disciplinary and multi-partner teams delineated by decision-relevant contexts shaped by geography, sector, and timing. Additionally, the approach is evolutionary and opportunistic, adapting to the influx of new constituencies—many of which are actively "cultivated" by the RISA teams—new advances in science and technology, an improved understanding of decision contexts, and responsive to the opportunities associated with climate events (e.g., droughts) and emerging policy initiatives.

RISA Vision 2020

The RISA teams are committed to refining the RISA model of climate services and to helping stakeholders effectively use science in the resolution of society's climate-related problems. The RISA program vision for 2020 is to:

> *Conduct innovative, inter-disciplinary, user-inspired, and regionally relevant research that informs resource management and public policy and builds the nation's capacity to prepare for and adapt to climate variability and change; and to provide that cutting-edge scientific information to public and private user communities, working closely with a National Climate Service to meet regional needs.*

Five overarching goals supporting this vision for the program have been identified:

1. *Provide continued leadership and innovation in developing and assessing regionally relevant climate research and decision-support products.* The RISA teams will build upon stakeholder networks and enhance their technical expertise to continue producing high-quality, stakeholder-inspired, and regionally-relevant research on how climate impacts affect human, natural, and built environments. As part of this goal, the RISA program will secure the necessary resources from NOAA, other federal agencies, foundations, and the private sector to increase both the depth and diversity of climate impacts issues investigated by RISA teams. The RISA program will also leverage resources to develop new RISA regions and/or partnerships within regions currently lacking RISAs.

2. *Improve the climate literacy of decision makers and build community capacity to adapt to climate.* Working in partnership with a wide variety of public and private entities, the RISAs will continue to play an important role in translating and conveying climate information to a diversity of current and emerging stakeholders, cultivating new audiences for climate products, and promoting the enhanced societal literacy on climate issues necessary to promote informed public policy.

3. *Inform policy through knowledge of the climate science landscape and dialogue with stakeholders.* By anticipating climate challenges and changing societal vulnerabilities, RISAs will support informed policy development by performing fundamental research on climate and climate impacts; serving as expert interpreters of climate science; assessing stakeholder

information needs; identifying and analyzing options for adapting to climate variations and climate change; and identifying entry points for climate information in operations and planning.

4. *Pursue new collaborations that enhance the development and use of climate information.* As regional research hubs, RISAs will connect university scientists, agencies, and information intermediaries such as Cooperative Extension with stakeholders on issues related to climate impacts research and decision support. Recognizing that climate variations and trends do not stop at the border, RISAs will expand collaborations with international partners such as the International Research Institute for Climate and Society (http://iri.columbia.edu).

5. *Better use/promote the expanding suite of capabilities within and outside of NOAA to support regional efforts to assess and prepare for climate variability and change.* RISAs will identify and draw from the suite of data and capabilities (e.g., past climate records, analyses of current climate events, forecasts of upcoming climate, and future projections), within and outside of NOAA for regional decision making. Through their direct interaction with stakeholders, RISAs will provide feedback on existing science, data, and tools, and identify new data sets, analysis, and modeling techniques needed to address resource management questions.

6. *Support transition of RISA research products, tools, and services to sustainable operations.* RISAs will collaborate with organizations having operational responsibility for delivery of climate information to identify institutional pathways, policy requirements, and innovative technical processes for transferring maturing RISA research for sustainable delivery by others.

The Relationship among the RISAs, NOAA, and a NCS

It is difficult to articulate a future vision for the RISAs without considering the likely near-term creation of a NCS, especially given the argument that the lessons of the RISA program should be part of the wisdom used to design the NCS. From the standpoint of the RISAs, two questions are particularly salient: first, how could the RISAs contribute to a NCS; and second, what do the RISAs need from NOAA to ensure this contribution?

Contributions of RISA to a NCS. The potential contributions of the RISA program to the NCS are foreshadowed both in the summary of RISA experience/lessons and the 5 RISA 2020 goals specified above. Specifically, the RISAs would be particularly valuable to the NCS in at least 5 critical areas:

1. Fundamental climate impacts and adaptations research;
2. Experimental research for decision support;
3. Assessment, analysis and translation of climate change uncertainties;
4. A regional base for climate impacts and adaptation expertise; and
5. The dynamic, evolutionary structure required to maintain contact with changing stakeholder needs.

The RISA teams are well positioned as a critical research arm of NCS due to their skill in identifying regional information needs and the opportunities, constraints and pathways to effective information delivery.

Necessary Contributions from NOAA (to the RISAs). Beyond obvious and chronic issues of funding (especially critical in an era of rapidly increasing user demands), the RISAs will need two types of support from NOAA as part of a NCS creation. First, a major function of RISAs is to generate knowledge about how to provide climate services; thus, an operational entity (i.e., a NCS) is needed to adopt this knowledge to realize and operationalize the full benefit of the RISA program. As part of this process, the NCS will need a transition mechanism, with resources attached, to support the adoption of RISA knowledge, tools, and outreach processes. Second, a pathway is needed within NOAA through which the knowledge gained by the RISAs can be systematically collected and considered as part of strategic decision-making within all relevant entities of NOAA. RISAs are in a unique position to identify priority research areas based on the input of users (and potential users) rather than relying solely on the intuitions of climate scientists.

1. Introduction

The societal challenges associated with climate change and variability are vast and growing and expressed in unique ways in a variety of sectors and regions. The National Oceanic and Atmospheric Administration's (NOAA) Regional Integrated Sciences and Assessments (RISA) program was created in 1995 to pioneer innovative mechanisms for enhancing the value of climate information and products for understanding and responding to these challenges at the regional scale. Since the program was established, a dispersed network of RISA projects has clearly demonstrated the value of having regional research centers work directly in sustained partnerships with local decision makers to meet this objective. RISAs have gained valuable insights with respect to bridging the gap between research and applications through this sustained experience. These lessons are particularly important as stakeholders[1] demand information and tools to support climate-change adaptation with increasing frequency and as efforts to design a National Climate Service (NCS) advance.

In this white paper, the past, present and future of the RISA program are explored, focusing on the relevance of the evolving "RISA model" of stakeholder-inspired research and activities for future relationships among RISA, NOAA, and the anticipated NCS. This discussion begins with a review of RISA's role in connecting the research and decision-making communities and the specific approaches devised by the RISA organizations to assess and meet user needs. The insights emerging from these discussions support the primary contribution of the paper: a vision of what the RISA program should look like in the year 2020. Central to this vision is the role of the RISA program serving NOAA and a NCS. This is addressed specifically, as are the future programmatic needs of the RISA organizations.

2. The RISA Program

Climate variability and change affect individuals, communities, and economies through tangible - and often costly - impacts on agriculture, water supply, human health, fisheries, coastal environments, forests, and infrastructure (Walther et al. 2002; Parmesan and Yohe 2003; Rosenzweig et al. 2008)[2]. These and other impact areas are attracting growing public concern and scientific attention.

[1] The term "stakeholders" is used here broadly to include anyone who has an interest in RISA products, including general research findings, models, data, forecasts, research papers, decision support tools, and other information. Examples of stakeholders include (but are not limited to) federal, state, and local resource managers; elected officials; community planners; utilities; tribal governments; the private sector (e.g., farmers, property owners, consulting firms, businesses); non-profit organizations; media; researchers; educators; and members of the general public.

[2] Consider, for example, the human, economic, and environmental impacts associated with several high impact events, including the 1997-98 El Niño event, the hurricane seasons of 2004 and 2005, the worst drought in 100 years in the Southeast (2007), the ongoing (since 1999) drought in the Southwest, the large wildfire years of 2000 and 2006 in the western U.S., and recent impacts in the Arctic from warming oceans and diminishing sea ice, including ecological shifts in the Bering Sea and increased coastal erosion.

While common challenges exist across the nation, sub-regions within the United States face unique climate impact and adaptation challenges due to regional differences in climate, geography, demography, ecology, and economies. For example, declining mountain snowpack and impacts on water supplies are a dominant concern in western states. In the Southeast, Hawaii, and the Pacific Islands, however, sea level rise and related coastal hazards are a dominant concern. In Alaska, the impact of declining sea ice on ecosystems, communities, cultures, and commerce is a major concern. These types of differences also exist within sub-regions and states.

Decision makers, particularly those at the regional and local level where climate impacts are felt most acutely, will need increasingly sophisticated information that integrates state-of-the-art physical and climate science with applied hazards assessments, economic impacts studies, and additional assessment from the social sciences. Decision makers will also need reliable access to technical expertise to help guide the application of this information in operations and planning.

NOAA's RISA program is uniquely positioned to support the country's growing decision support needs for climate adaptation. RISAs are dynamic, university-based teams specializing in research on the regional impacts of climate variability and change and the application of this information in decision making. RISA teams concentrate on specific climate impacts of importance to their stakeholders (Table 1), including but not limited to: agriculture, water resources, drought planning, wildland fire, fisheries, coasts, transportation, and public health.

The first RISA team, the Climate Impacts Group, was established in 1995 in response to the recognized need for more spatially explicit climate information. Additional RISA Centers have been added since that time to investigate climate impacts and applications in other parts of the U.S. As of January 2009, NOAA's Climate Program Office supports nine RISAs covering 23 states, three U.S.-Flag Pacific Islands, and three U.S.-Affiliated Pacific Islands (Figure 1, Table 1). A new RISA spanning Arkansas, Louisiana, Mississippi, Oklahoma, Tennessee and Texas began in September 2008.

Central to the RISA approach are commitments to process, partnership, trust building; assessments of stakeholder decision-making needs and contexts; and evaluation of institutional and political constraints to using climate knowledge. RISA teams are effective because they have been able to create strong, long-term relationships with stakeholders from the public and private sectors, including local, regional, and state governments, federal agencies, tribal governments, utilities, the business community, national and international non-profit organizations, and educational institutions. These relationships provide mutually beneficial opportunities to:

1) increase stakeholder understanding of climate, climate impacts, and their relevance to the day-to-day management of resources and communities;
2) better understand the research needs of the stakeholder community;
3) develop and evaluate new decision-support products that help integrate climate information into decision making; and
4) increase the awareness and use of existing climate products from NOAA and other climate organizations.

In response to (and in some cases in anticipation of) demands from stakeholders, RISA activities have expanded from a focus on seasonal to decadal climate variability to include the development and application of information related to climate change. In some cases RISAs have adjusted to growing stakeholder needs by expanding into adjacent states. For example, the Southeast Climate Consortium began as the Florida Consortium in 1998. In 2003, they expanded into Georgia and Alabama, states with similar climate conditions and similar information demands from stakeholders. Expansion into adjacent states has been accomplished through leveraging NOAA funds for a RISA team with funds from other sources.

RISA	States Covered	URL	Current Areas of Research
Alaska Center for Climate Assessment and Policy (ACCAP)	Alaska and the U.S. Arctic	http://www.uaf.edu/accap/	Water resource management, transportation, forest fires, food security
California Applications Program (CAP)	California and Nevada	http://meteora.ucsd.edu/cap/	Water resource management, forest fires, snowpack, human health
Carolinas Integrated Sciences and Assessments (CISA)	North and South Carolina	http://www.cas.sc.edu/geog/cisa/	Water resource management, forestry, coastal impacts
Climate Assessment for the Southwest (CLIMAS)	Arizona, New Mexico	http://www.ispe.arizona.edu/climas/	Water resource management, forestry, forest fires, snowpack, human health, agriculture
Climate Impacts Group (CIG)	Washington, Oregon, Idaho	http://www.cses.washington.edu/cig/	Water resource management, forestry, snowpack, fish, coastal impacts
Pacific RISA	Hawaii, Republic of the Marshall Islands, Commonwealth of the Northern Mariana Islands, Guam, Federated States of Micronesia, American Samoa, Republic of Palau	http://research.eastwestcenter.org/climate/risa/	Water resources management, coastal and marine impacts, health impacts, social and cultural impacts, disaster risk management
Southeast Climate Consortium (SECC)	Florida, Georgia, Alabama	http://secc.coaps.fsu.edu/members/coaps.htm	Agriculture, forestry, water resource management

Southern Climate Impacts Planning Program (SCIPP)	Arkansas, Louisiana, Mississippi, Oklahoma, Tennessee and Texas	http://www.southernclimate.org	Drought, water resource management, integrated hazard management, community planning
Western Water Assessment (WWA)	Colorado, Utah, Wyoming	http://wwa.colorado.edu	Water resource management, agriculture, snowpack

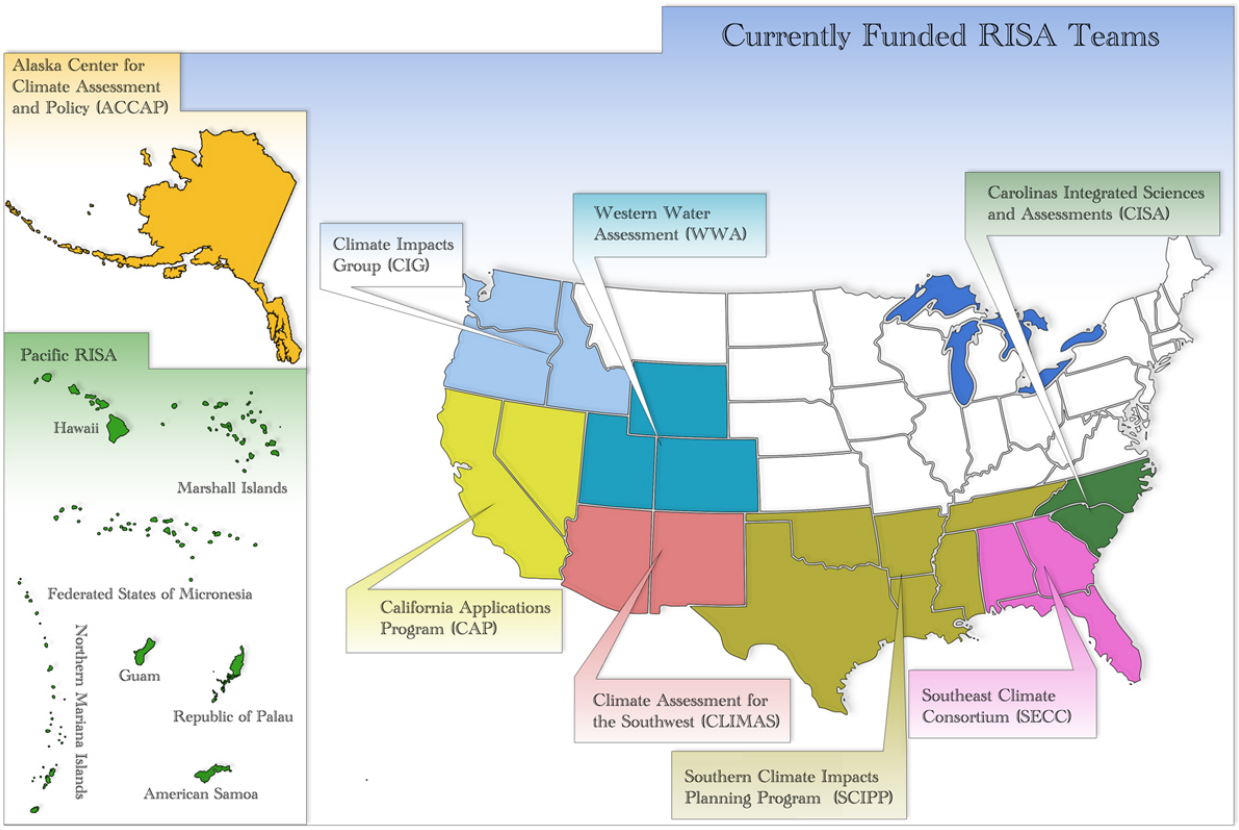

Figure 1, Table 1. Currently funded RISA teams as of January 2009. **Figure courtesy of NOAA's Climate Program Office. Table adapted from Snover et al. 2007.**

Lessons Learned in Delivering Climate Services through the RISA Model

A fundamental strength of the RISA program is the development of knowledge networks within and between RISAs and their stakeholder communities that facilitate sharing insights on developing regional capacity to address climate impacts. The RISAs work together, learning from one another and applying innovative scientific research and decision support to help solve regional and local problems related to climate variability and change.

The RISA experience has taught us many lessons (NOAA OGP, 2003). Key lessons with implications for regional and national climate services are identified here and illustrated by the series of short cases studies from the RISA program in Section 2.1.

- *Building trust requires a sustained effort*. Effectively engaging decision makers requires sustained, iterative, and consistent contact. Time is required for stakeholders to develop familiarity with concepts related to climate, climate impacts, and planning. Time is also required to firmly establish a RISA team's credibility with stakeholders as a reliable source of regional expertise.

- *Integrated and interdisciplinary climate information and research is required*. Answering the real-world questions raised by regional stakeholders about climate impacts requires integrated observations, forecasts, projections, research, assessment, data management, and outreach across varying scales of time and space. Collaborations across disciplines and agencies in both the public and private sector are necessary to effectively address complex issues such as drought, endangered species, and wildfire.

- *Information must be contextual and relevant.* Overcoming barriers to using climate information, forecasts, and tools requires understanding the context in which decision makers operate. Products must be relevant to the timing and spatial scale of decision making. The role of institutional constraints, laws, and organizational structure in affecting the use of climate information must be known. Identifying internal champions and early adopters within governments, agencies, and institutions can provide important leverage points for building regional capacity to manage climate impacts.

- *Proactive engagement is required.* Cultivating the audience for climate knowledge and building the capacity for climate decision support and forecast use requires proactive communication with all levels of an organization and the stakeholder community. Successfully anticipating and responding to stakeholder needs requires two-way communication between the research community and stakeholders. Moreover, partnerships between researchers and stakeholders require mutually beneficial outcomes and respect for institutional constraints.

- *A dynamic and flexible organization is required*. Climate services and decision support are ongoing processes that change over time due to changes in science, technology, and relationships with the stakeholder community and partnering organizations. Climate

service providers must track salient issues, keep abreast of cutting-edge science, build capacity by engaging top experts, and expand relevance to meet changing climates, societal needs, and technologies.

2.1 Case Studies

Drought Decision Support: The Dynamic Drought Index Tool
RISA(s): Carolinas Integrated Sciences and Assessments, Climate Assessment for the Southwest

Decision support success depends on identifying stakeholder needs, understanding legal and institutional constraints, and evolving to meet expanding needs. The 1998–2002 drought demonstrated that the humid Carolinas could experience significant water shortages, agricultural and forestry losses, and curtailed industrial activities. Carolinas stakeholders identified Federal Energy Regulatory Commission (FERC) relicensing as the most important drought-sensitive water resources issue, and severe drought in 2007 reinforced the need to monitor drought for relicensing requirements.

In order to address diverse decision-maker needs, the Carolinas RISA developed a Dynamic Drought Index Tool (DDIT), which allows users to select and aggregate a variety of drought indices at custom spatial and temporal scales. One classification method conforms to intervals defined in state drought legislation. The Catawba-Wateree Drought Management Advisory Committee (DMAC) has used the DDIT to update and improve its low-inflow protocols. Iterative usability assessments with regional stakeholders have been used to improve DDIT displays and uncertainty characterizations, and to develop capabilities for monitoring FERC low-inflow triggers used operationally by the DMAC.

Acting on a National Integrated Drought Information System (NIDIS) recommendation to expand DDIT to other parts of the United States, the Southwest RISA (Climate Assessment for the Southwest) is testing DDIT. The teams have developed generalizable open-source code, to be housed at the Northeast Regional Climate Center, which will facilitate operational use and customization for other regions.

A Multi-Agency, Multi-Factor Process for Wildfire Decision-making: National Seasonal Assessment Workshops
RISA(s): Climate Assessment for the Southwest, California Applications Program, Southeast Climate Consortium, Western Water Assessment, Climate Impacts Group, Alaska Center for Climate Assessment and Policy

Wildland fires, caused by complex interactions between climate, vegetation, and society, cost the United States $1 billion annually. Successful climate services supporting fire management and prediction require multi-agency coordination and multidisciplinary perspectives. In anticipation of sustained dry conditions in 2000 in the southern United States, RISAs convened climatologists and fire managers for discussions about using El Niño/Southern Oscillation (ENSO) information to predict fire potential. The scientific knowledge was too new for fire operations, but sustained

scientist-management exchanges identified climate information insertion points for fire management decisions.

In 2003, RISAs, the National Interagency Coordination Center (coordinating the Department of Interior and USDA Forest Service firefighting entities) and the Program for Climate, Ecosystem, and Fire Applications collaborated on pre-season fire potential outlooks for the conterminous U.S. and Alaska through a decision support process called the National Seasonal Assessment Workshops (NSAW). The process requires collaboration of fire management, forestry, vegetation, and climate experts. NSAW contributors include NOAA's Climate Prediction Center (CPC), Earth System Research Laboratory (ESRL), Scripps Experimental Climate Prediction Center, Regional Climate Centers, and RISAs. NSAW products are part of the NIDIS Drought Portal.

The National Multi-Agency Coordinating Group uses NSAW outlooks, which now include all of North America, to allocate firefighting resources, make prescribed fire decisions, and brief the U.S. Secretary of Agriculture. The U.S. Northern Command uses NSAW information to prepare for fire suppression and disaster troop deployments. Key climate-related fire prediction research issues identified by NSAW partners include monsoon onset prediction, improved forecasting for Alaska, and prediction of multi-day atmospheric blocking events.

Opening Doors to New Climate Approaches: Paleoclimate and Climate Change Science in the Colorado River Basin
RISA(s): Western Water Assessment

Barriers to using climate knowledge and products include lack of institutional capacity, need for translation of technical details, and mismatches in operational, policy, and research paradigms. Sustained and iterative stakeholder engagement can overcome barriers by improving mutual understanding of decisions and science capabilities. Colorado River Basin (CRB) drought, with severe impacts in 2002 (25 percent of average inflow to Lake Powell, record wildfires, water restrictions in Denver), prompted water resources managers to ask: How unusual is severe drought? Does likelihood of reoccurrence justify infrastructure investments to mitigate drought? Are instrumental streamflow records adequate baselines for drought planning?

Through interactions with water managers in the CRB, Western Water Assessment (WWA) paleohydrologists demonstrated greater drought severity and increased streamflow variability prior to the gaged record, prompting managers to revise worst-case scenarios. Through sustained partnership, the managers and scientists developed satisfactory methods for matching annual paleohydrologic data with management model daily time steps, and they designed new methods for characterizing uncertainty in the paleostreamflow estimates. Agencies and water providers now using the paleostreamflow estimates in modeling and planning include Denver Water, the U.S. Bureau of Reclamation, and the Colorado River Water Conservancy District.

Tangible outcomes of this evolving process include contributions to a National Research Council report on the CRB (NRC 2007a), additional stakeholder-requested paleostreamflow

reconstructions, and technical workshops. Western water resource managers invited WWA to participate in formal policy processes and develop an appendix to the environmental impact statement for CRB shortage sharing during drought.

Developing Integrated Climate Information for the Pacific: PaCIS
RISA(s): Pacific RISA

To build resilient and adaptive Pacific Island communities, stakeholders need help assessing climate risks to local economies, social systems, culture, infrastructure, agriculture, natural resources, and public health. The Pacific RISA, in collaboration with the Pacific ENSO Applications Climate (PEAC) and regional weather services, has supported the development of a system that facilitates risk assessments, decision-support tool development, planning processes, public education, and outreach.

The Pacific Climate Information System (PaCIS) uses integrated, interdisciplinary methods to link information and knowledge through networking and exchange. The PaCIS process respects culture and local knowledge and emphasizes dialogue among local experts to inform scientific research and the development of research products. Participatory processes and shared learning are used to strengthen communications and partnerships. Sustained collaborations bridge regional organizations (e.g., the Pacific Regional Environment Programme); weather services (Forecast Offices in the American Flag and U.S. Affiliated Pacific Islands; National Weather Service Pacific Region; Australia, New Zealand, Fiji; WMO Pacific Region), government, agriculture, disaster, coastal, and water resources management.

Workshops in 2005–06 in the American Flag and U.S. Affiliated Pacific Islands led to the formation of task forces in each jurisdiction to develop climate-change adaptation strategies. Relationships established with the disaster-management community in Hawaii led to incorporation of climate information in the State of Hawaii hazard mitigation plan. The Pacific RISA is one of the institutions specifically mentioned in the FEMA-approved plan for risk assessment and reduction.

Local Planning for Climate Change
RISA(s): Climate Impacts Group, Alaska Center for Climate Assessment and Policy

Climate and environmental stresses such as drought or floods motivate institutional change. The Climate Impacts Group (CIG) has worked with stakeholders in Washington, Oregon, and Idaho since 1995 to develop regional capacity for managing climate-related stresses on water supplies, forests, aquatic ecosystems, and coasts. Temperature-driven declines in mountain snowpack, combined with growing population and competing demands for over-allocated summer water supplies, now stress local and state governments in the region.

Recognizing the need to advance state-wide discussion on climate impacts and adaptation, King County, Washington convened a conference in 2005 to discuss projected climate change impacts and adaptation strategies for Washington. “The Future Ain’t What it Used to Be: Planning for

Climate Disruption" drew more than 700 participants from across disciplines and levels of government, including researchers, public officials, tribal representatives, private sector leaders, and citizens. The CIG worked closely with conference organizers to structure the meeting and prepare white papers and other materials distributed at the conference.

The King County conference provided many tangible outcomes. The conference prompted King County to establish its climate change action and preparedness team in 2006, and to complete the county's first comprehensive climate change action plan in 2007. The conference also led to the development of a climate change adaptation planning guidebook by the CIG and King County written for local, regional, and state governments around the nation (Snover et al. 2007). Finally, continued dialogue with state leaders since the conference contributed to new commitments from the state for adapting to climate change. This included funding a $1.5 million statewide study of climate change impacts resulting in The Washington Climate Change Impact Assessment report (available at http://cses.washington.edu/cig/res/ia/waccia.shtml), and sponsoring multi-stakeholder working groups to develop recommendations for the state on adapting to climate change.

The Alaska Center for Climate Assessment and Policy is now using the Snover et al 2007 framework to assist the Fairbanks North Star Borough in climate change vulnerability assessment and adaptation planning (http://www.investfairbanks.com/Taskforces/climate.php).

Online Tools for Agriculture and Natural Resources: AgClimate
RISA(s): Southeast Climate Consortium

Iterative end-user needs assessments and multidisciplinary expertise form the foundation for developing valued online tools. However, only partnerships anchored in commitments to outreach and collaboration with stakeholders can sustain ongoing public sector product evolution.

The Southeast Climate Consortium (SECC) developed AgClimate, a decision support system including seasonal climate forecasts and tools to help producers understand and plan for climate variation. AgClimate was developed through multi-disciplinary research and outreach, including partnerships with Cooperative Extension Services in Florida, Georgia, and Alabama. These partnerships facilitated participation of sector-specific end-users throughout the design and development process. For example, extension agents and farmers provided feedback on the development of crop yield forecast tools, whereas forest managers provided insights into the development of Keetch-Byram Drought Index forecasts.

Several additional tools were developed in direct response to requests from farmers and extension agents, including: visualization of ENSO effects on crop yields; forecasts of growing degree days and chill unit accumulation (important for forecasting crop flowering and maturation); and climate and commodity outlooks, produced in partnership with Extension.

SECC is now analyzing the economic benefits of AgClimate. Anecdotal evidence of its impact includes the use of more than 50 SECC outlooks in agricultural commodity publications distributed to over 10,000 people in 10 states. Moreover, Tampa Bay Water, which supplies water to municipalities and counties in the Tampa area, regularly uses information from AgroClimate as part of its water balance optimization planning. In 2007-08, the SECC began transferring AgroClimate to New Mexico and to the North Carolina State Climate Office.

Research to Operations: Downscaling and Verifying Seasonal Climate Outlooks
RISA: Climate Assessment for the Southwest

RISAs must necessarily focus efforts on specific regions and sectors to build relationships and deep understanding of stakeholder issues related to climate, impacts, decision processes, and adaptation alternatives. Not every region in the U.S. has a RISA and many sectors have not yet been engaged by a RISA. Further, RISAs have a research mission, in contrast to the operational mission of the NWS. From a national perspective, a challenge for the RISA program is to leverage work in one region throughout NOAA NCS, serving new sectors and regions.

Working across several sectors, CLIMAS identified significant barriers to the use of seasonal climate outlooks, including pervasive product misinterpretation, limitations in placing forecasts in context with historical or recent observations, lack of forecast skill expressed in ways relevant or meaningful to users, and lack of local-scale outlooks. While the original stakeholder engagement was limited to a few sectors within the Southwest, the resulting research has demonstrated relevance and impact for new sectors and throughout the U.S. Through workshop discussions, training courses, surveys, and interviews, CLIMAS determined aspects of the forecast products and their communication leading to misinterpretation. Improved language and product formatting has been incorporated into NWS operations, through briefing language, product descriptions, and implementation of entirely new product formats.

CLIMAS developed the Forecast Evaluation Tool (FET) which provides tutorials on forecast interpretation, tools for analog exploration of historical conditions and recent observations in terms consistent with those used for the outlooks, and tools for examining and quantifying the past performance of the forecasts at regional scales. Through the NWS Climate Test Bed, the FET is now being transferred and incorporated within Climate Prediction Center (CPC) operations to enable dynamic user-controlled forecast verification for the entire range of CPC climate outlook products. Further, in collaboration with the Climate Services Branch (CSB) of the Office of Weather, Water, and Climate Services, over 250 NWS forecasters at local Weather Forecast Offices (WFOs), including at least one forecaster at each of the 122 WFOs nationwide, have been trained to use the FET in providing operational climate services through the WFOs.

CLIMAS also developed regression-based techniques for downscaling the NWS seasonal climate outlooks to individual stations. The NWS Western Region and CSB worked with CLIMAS to refine and implement the techniques, producing a Local 3-Month Temperature Outlook (L3MTO) that has transitioned from experimental status for several hundred stations to an official NWS product issued by the CPC for over 4000 stations, with concomitant system-wide

WFO training. The L3MTO formats and their diversity were designed, in collaboration with CLIMAS, to mitigate issues leading to misinterpretation. Further, the FET was extended to allow users to evaluate the skill of the L3MTO, with a direct link to the FET incorporated within the official L3MTO product. The FET's user registration has identified an increasing range of sectors evaluating forecast skill, including agribusiness, finance, insurance, and construction industries, and community planners.

3. RISA 2020

Effective response to climate variability and change requires a two-pronged approach coupling scientific assessment with application and communication at all scales. Both science and application are necessary to "meet national, regional, private and local climate-related needs, and to foster the timely adoption and effective use of commercially valuable information and technology throughout the U.S. economy" (Pulwarty et al, in press; U.S. Congress 1998; U.S. Congress 2007; NRC 1999; Clark et al. 2001).

The regional RISA teams have been developing and refining this two-prong approach to climate response for over a decade. Looking to the future, the **RISA program vision for 2020** is to:

> *Conduct innovative, inter-disciplinary, user-inspired, and regionally relevant research that informs resource management and public policy and builds the nation's capacity to prepare for and adapt to climate variability and change; and to provide that cutting-edge scientific information to public and private user communities, working closely with a National Climate Service (NCS) to meet regional information needs.*

RISAs expect to accomplish this vision through the following goals.

4.1. Provide continued leadership and innovation in developing and assessing regionally relevant climate research and decision-support products.

RISAs will enhance their technical expertise to continue producing high-quality, stakeholder-inspired, and regionally-relevant research on how climate impacts affect human, natural, and built environments. RISA teams will work at the cutting edge of scientific discovery to anticipate climate challenges and decision support needs, and to assess vulnerabilities in diverse sectors. Guided by their familiarity with regional climate-information users, RISAs will utilize all available tools, products, and services, including those developed by other agencies, universities, and private sector providers, to develop prototype products for a range of stakeholders within a given decision context. When RISAs develop products themselves, they will do so in partnership with both stakeholders and the operational institutions poised to employ them.

As part of this goal, the RISA program will secure the necessary resources from NOAA, other federal agencies, foundations, and the private sector to increase both the depth and diversity of climate impacts issues investigated by RISA teams. RISAs will integrate more social science expertise (e.g., economics, anthropology, geography, law, risk perception and assessment) where

appropriate to complement its existing strengths in the physical sciences. RISAs will address emerging challenges such as the nexus of climate change mitigation and adaptation in energy supply and production, the impacts of ocean acidification on coastal ecosystems, and the impacts of climate change on cross-border governance. The RISA program will also leverage resources to develop new RISA regions and/or partnerships within regions currently lacking RISAs. In some cases, increasing geographical coverage will be accomplished by adding states to existing RISAs. When this occurs, sufficient funding to the university partners in the new state(s) will be required to sustain a viable and equitable partnership.

4.2. Improve the climate literacy of decision makers and build community capacity to adapt to climate.

A key goal of the RISA program is to connect science and society, thereby creating informed communities in the U.S. that will effectively use climate information in decision making. RISAs will continue to play a critical role in interpreting and translating climate information for multiple stakeholders, including policy makers, resource managers, city, county, and municipal officials, and the general public. RISAs will utilize the rapidly evolving cyber infrastructure and communication technologies with their stakeholders to facilitate information sharing, collaboration, and research.

RISAs' role in education is also important in fostering an informed society. Through their university base, RISAs develop, encourage, and support multi-disciplinary curricula used to educate the next generation of innovative climate scientists and decision makers. These new thinkers, trained by faculty who are integral to RISAs, enter the work force with the technical knowledge and skills required to address the impacts of climate variability and change in a world of multiple stresses. RISAs will expand their mission to address broad societal needs for public education (i.e. museums and zoos) and pre-university (K-12) climate education by partnering with education and outreach projects at NOAA and other agencies, such as the National Science Foundation and the National Park Service.

4.3. Inform policy through knowledge of the climate science landscape and dialogue with stakeholders.

Decision makers are increasingly turning to the RISAs for guidance on how climate variability and climate change affect pressing social, environmental, and economic issues in their region. Because RISAs sit at the nexus of developing and applying regionally integrated climate science, they are uniquely positioned to help decision makers understand how climate variability and change affect their communities, and how this information can be used to develop more climate-resilient policies. RISAs will support informed policy development by:

- Performing fundamental research on climate and climate impacts;
- Serving as expert interpreters of climate science;
- Assessing stakeholder information needs;
- Identifying and analyzing options for adapting to climate variations and climate change; and

- Identifying ways in which climate information could be used in operations and planning.

4.4. Pursue new collaborations that enhance the development and use of climate information.

RISAs are well positioned to pursue new collaborations with a variety of partners in the public and private sector. As regional research hubs, RISAs will connect university scientists, agencies, and information intermediaries such as Cooperative Extension with stakeholders on issues related to climate impacts research and decision support. Working in partnership increases opportunities for shared learning between the RISA program and the partnering organization(s). The partnerships also create pathways for developing, improving, and transferring the knowledge and decision-support resources needed by partnering organization and their stakeholders. Recognizing that climate variations and trends do not stop at the border, RISAs will expand collaborations with international partners such the International Research Institute for Climate and Society.

4.5. Better use/promote the expanding suite of capabilities within and outside of NOAA to support regional efforts to assess and prepare for climate variability and change.

Extraordinary technological development will help federal agencies monitor the earth's climate system more intensely and analyze data using increasingly sophisticated approaches (NASA 2007; NOAA 2005; NRC 2007b). These agencies recognize that such efforts must satisfy societal needs, and that there must be cooperation among a broad array of institutions and individuals.

RISAs will identify and draw from the suite of new data and capabilities within and outside of NOAA for regional decision making, such as tree-ring derived and historical information about climate, analyses of current climate and its impacts, seasonal or longer forecasts, and decadal and longer projections. RISA's direct interaction with stakeholders allows RISA to orient stakeholders towards appropriate science, data, and tools, expanding the user base for these products. This interaction also creates opportunities to provide feedback on existing science, data, and tools, and to identify new data sets, analysis, and modeling techniques needed to address resource management questions.

4.6 *Support transition of RISA research products, tools, and services to sustainable operations.*

RISAs have a research focus. The products, tools, and services they provide are prototypes that must be shifted to others for operational production and maintenance with long-term sustainability. The transition of research to operations is neither easy nor assured. Operational entities, including the private sector, face formidable challenges in adapting their internal product generation and service processes, installing and maintaining new technologies, shifting personnel responsibilities, changing relationships with users, and providing internal and external training. RISAs will collaborate with organizations having operational responsibility for delivery of climate information to identify institutional pathways, policy requirements, and innovative

technical processes for transferring maturing RISA research for sustainable delivery by others. In moving research to operations, RISAs will work with operational organizations to adapt the prototypes to serve additional users, regions, and sectors, where appropriate, and to facilitate efficient integration of subsequent research advances.

4. What RISA offers to NOAA and National Climate Service through RISA 2020

At full capacity, the RISA program can offer NOAA and a NCS the critical research platform needed for identifying and analyzing regional-scale climate impacts and decision support needs and for developing experimental and prototype regional climate services (e.g., tools, training modules, stakeholder fora and newsletters, synthesis documents). More specifically, RISAs offer the following critical elements upon which to build the regional services arm of a NCS:

1. *Climate impacts and adaptation research*. RISAs perform critical research on regional climate impacts and adaptation based on anticipated and expressed needs of stakeholders. This research feeds into the development of tools and building community resilience to climate variability and change. The ability to evaluate and communicate uncertainties across projections is an essential component of this work. For example, several RISA teams, as well as members of NOAA labs and other universities, are assessing model uncertainties surrounding future Colorado River streamflow projections based on climate change scenarios. The goal is to aid water managers of the basin in their analyses of the wide range of existing water supply scenarios for the future.

2. *Experimental research for decision support.* RISAs provide a focal point for developing experimental decision support tools for current and emerging problems and opportunities related to climate impacts on communities and the environment. These products, once tested successfully at the RISA level, can benefit receiving agencies by expanding the services provided by operational agencies, thereby enhancing their relevance for stakeholders and facilitating agency goals and objectives. Examples include:

    a. Developing regional climate variability and change impacts tools (e.g., the Dynamic Drought Index and AgroClimate tools described in Section 3.1) and a seasonal fire prediction tool for Alaska, which is currently under development at ACCAP);

    b. Testing transferability of climate impacts tools across regions (e.g., AgroClimate and Dynamic Drought Index Tool developed in southeastern U.S. and being tested in southwestern U.S., described in Section 3.1);

    c. Enhancing NOAA paleo research (e.g., paleo climate information for Colorado River Basin, described in Section 3.1), seasonal forecasts (e.g., AgroClimate and local 3-month temperature outlooks described in Section 3.1 builds on NOAA data and forecast information), and other climate products by linking them with

user-based web tools and evaluation tools (e.g., the Forecast Evaluation Tool, described in Section 3.1);

d. Working with NOAA entities (e.g., CPC, ESRL) to improve the usability of NOAA products and to facilitate co-development of new products and tools based on user needs assessed by RISA teams (e.g., the local 3-month temperature outlooks and Forecast Evaluation Tool, described in Section 3.1).

e. Working with Native Americans and Alaska Natives to expand cross-cultural communication and learning related to climate and environmental change (Pacific Islands RISA, CLIMAS, ACCAP).

Assessment, analysis, and translation of climate information products. RISAs provide a valuable service in assessing, analyzing, and translating a range of climate information products developed by NOAA-funded research and an emerging NCS. These include paleoclimate data analyses, historical trends in climate, seasonal climate forecasts, attribution information, decadal variability, and climate change projections. Additionally, RISAs effectively develop prototype regional climate services that can be transitioned to the emerging NCS and regional service hubs as they develop.

3. *Direct connections with regionally-based stakeholders*. RISAs provide direct connections with stakeholders, thereby offering a regional base of expertise on climate impacts and adaptation. Our networks include federal, state, and local agencies, communities, non-profit organizations, research organizations, and others. RISAs also provide focal points for cross-agency (federal and state, and cross-federal) collaborations for investigating climate sensitive resource management and public policy issues.

4. *Dynamic, evolutionary structure*. RISAs offer a dynamic evolutionary structure capable of adjusting to anticipated and expressed needs in the stakeholder community. The university-based design of the RISA program allows for ongoing access to cutting-edge research and technical expertise in a wide variety of fields that can be utilized as needed.

In short, the RISA program delivers state-of-the-art research that is responsive to expressed or anticipated local stakeholder needs. The program's collaborative approach means that a wide range of expertise can be applied dynamically to the complex climate challenges facing society.

5. What RISA Needs from NOAA to Accomplish RISA 2020

NOAA's vision to provide improved understanding of the atmospheric, oceanic, and coastal processes necessary for future social and economic decision making (NOAA 2005) requires knowledge about the context in which such decisions are made and the time and spatial scales at which information is needed. RISA 2020 contributes to NOAA's vision by answering these questions, but RISAs will require additional support from NOAA and a NCS to fully realize these shared goals. Understanding the decision contexts, identifying ways in which climate information could benefit those decisions, and developing trusted relationships with stakeholders

requires a longer-term presence in a region and on projects than is afforded with the standard 1-3 year research grant cycle.

1. ***NOAA needs to continue to recognize the growing demand as well as the existing need for RISA-style centers***.

   A major challenge to accomplishing the RISA 2020 goals is the absence of regional NOAA capacity, especially for providing longer-term climate information (e.g., decadal and beyond) at scales appropriate for regional to local level decision making.

2. ***Transitioning decision support tools to operational entities***

   Another significant challenge is the lack of a NCS to adopt RISA prototype tools, models, and services and to assume responsibility for the routine delivery of mature regional climate service products. RISAs, by design, work with stakeholders to identify both opportunities and gaps for using climate information in decision making. As the utility of experimental RISA decision support tools is tested and proven, these tools need to be moved from the RISA team into operational entities for continued support.

   This transitioning is beneficial in multiple ways. First, it creates opportunities for operational agencies to provide proven new products and services to their stakeholders. Second, it provides stakeholders reliable access over time to a regularly updated decision support product. Finally, it allows RISAs to continue engaging their network of stakeholders in an iterative process for identifying and developing the next generation of new climate service information and products.

   In order to leverage over a decade of work with stakeholders and take advantage of substantial future work, **it is imperative that NOAA facilitate regional and national RISA product delivery.** NOAA can foster a culture of cooperation between agencies for transitioning products. NOAA can also streamline the Memorandum of Understanding process used to guide product transitions, and establish a NOAA support team or nucleus of contacts to help with the transition process. Adequate technical and fiscal resources must be provided to both the RISA and receiving operational agency to support the training required to successfully transition the product.

3. **Create institutional pathways for informing all NOAA line offices (e.g., observations, data, research, modeling, services efforts) of high priority research and observations needs for addressing critical climate information and decision support gaps at the regional scale**.

   RISAs have accumulated an untapped wealth of knowledge about the spectrum of regional climate information needs for anticipating, adapting, and mitigating changes in climate. Within a NCS, investments in future climate research need to be firmly grounded in local and regional stakeholder information needs, and should be based on a well-defined decision

process where interactions with stakeholders play a central role in guiding priorities. These research investments would, of course, build on knowledge developed through more fundamental research endeavors.

4. Finally, NOAA needs to help RISAs meet rapidly growing stakeholder demands by **providing or leveraging substantial additional funding** to 1) expand the RISA program into regions currently lacking a RISA, and 2) increase the depth and diversity of climate impacts research at existing RISAs.

6. Conclusion

The ability of communities and regions to manage and prepare for climate impacts is a function of the availability of accurate and reliable scientific information coupled with an ability to apply this information to regional and local needs. Strong leadership and resources to address the climate challenge in the face of multiple stresses is also critical.

In the 13 years since the RISA program began, the RISA model has successfully demonstrated that:

1. Regionally-relevant information on climate impacts can inform decision making in ways that contribute to more climate-resilient resource management and communities;

2. Sustained interaction with stakeholders is essential to gaining the trust of stakeholders, developing climate literacy among stakeholders, developing effective two-way channels of communication for getting stakeholder input into research needs, and getting climate information integrated into decision making. This is particularly true given the uncertainties that exist in applying climate impacts information and the time required to help stakeholders both understand and work with those uncertainties;

3. Regional entities like the RISA teams play an important role in promoting the use of, and making enhancements to, NOAA and other agency climate products, tools, and services; and

4. Regional climate research centers based on sustained partnerships with stakeholders have an important role to play as an experimental research arm for developing and testing climate products and services.

As we look towards 2020 the RISA programs aim to build on our successes and serve as a model for climate impact and adaptation research and application. The RISA program is at the forefront of helping stakeholders understand and respond to a variety of climate challenges and opportunities. In combination with a NCS and adequate resources, the RISA teams are uniquely positioned to aid the nation in its efforts to develop well-informed, science-based adaptation strategies in the face of climate variability and change.

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