EXPANDING CLIMATE SERVICES AT THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA): DEVELOPING THE NATIONAL CLIMATE SERVICE

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY AND ENVIRONMENT

COMMITTEE ON SCIENCE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED ELEVENTH CONGRESS

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May 5, 2009

EXPANDING CLIMATE SERVICES AT THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA): DEVELOPING THE NATIONAL CLIMATE SERVICE

TUESDAY, MAY 5, 2009

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON ENERGY AND ENVIRONMENT,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, DC.

The Subcommittee met, pursuant to call, at 10:00 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Brian Baird [Chair of the Subcommittee] presiding.

BART GORDON, TENNESSEE
CHAIRMAN

RALPH M. HALL, TEXAS
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Subcommittee on Energy and Environment

Hearing on

Expanding Climate Services at the National Oceanic and Atmospheric Administration (NOAA): Developing the National Climate Service

Tuesday, May 5, 2009
10:00a.m. – 12:00p.m.
2318 Rayburn House Office Building

Witness List:

Panel I

Dr. Jane Lubchenco
Under Secretary, National Oceanic and Atmospheric Administration

Panel II

Dr. Arthur DeGaetano
Director, Northeast Regional Climate Center

Dr. Eric J. Barron
Director, National Center for Atmospheric Research

Dr. Philip Mote
Director, Oregon Climate Change Research Institute and Oregon Climate Services, Oregon State University

Mr. Richard J. Hirn
General Counsel and Legislative Director, National Weather Service Employees Organization

Panel III

Dr. Michael L. Strobel
Director, National Water and Climate Center, United States Department of Agriculture

Mr. David Behar
Deputy to the Assistant General Manager, San Francisco Public Utilities Commission

Mr. Paul Fleming
Manager, Climate and Sustainability Group, Seattle Public Utilities

Dr. Nolan Doesken
State Climatologist for Colorado, and Senior Research Associate, Colorado State University

HEARING CHARTER

SUBCOMMITTEE ON ENERGY AND ENVIRONMENT
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

Expanding Climate Services at the National Oceanic and Atmospheric Administration (NOAA): Developing the National Climate Service

TUESDAY, MAY 5, 2009
10:00 A.M.—12:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

Purpose

On Tuesday, May 5, 2009 the Subcommittee on Energy and Environment of the Committee on Science and Technology will hold a hearing on *Expanding Climate Services at the National Oceanic and Atmospheric Administration (NOAA): Developing the National Climate Service.*

The purpose of the hearing is to hear expert testimony on options for expanding the delivery of climate services by the National Oceanic and Atmospheric Administration (NOAA). The hearing will also explore the role of other federal agencies in building a national infrastructure to deliver climate information to support the development of national, regional and local strategies to adapt to climate variability and change.

Witnesses

Panel I

Dr. Jane Lubchenco, Under Secretary, National Oceanic and Atmospheric Administration, U.S. Department of Commerce. Dr. Lubchenco will discuss the current climate services available through NOAA's various programs and offices; the agencies' plan for internally organizing a National Climate Service; and how and to whom services are delivered.

Panel II

Dr. Arthur DeGaetano, Director, Northeast Regional Climate Center (NRCC). Dr. DeGaetano will discuss the products and services of the regional climate centers, specifically the Northeast Regional Climate Center. Dr. DeGaetano will also discuss regional data users and give examples of how the NRCC services influence regional management and climate decisions.

Dr. Eric J. Barron, Director, National Center for Atmospheric Research. As Chairman of the Climate Service Tiger Teams Coordinating Committee, Dr. Barron will discuss how current climate services are organized and the potential impact of a coordinated, national climate service. In addition, Dr. Barron will discuss different organizational scenarios for a national climate service, as outlined in the Tiger Team Coordinating Committee and the National Academy of Sciences (NAS) Report.

Dr. Philip Mote, Director, Oregon Climate Change Research Institute and Oregon Climate Services and Professor, College of Oceanic and Atmospheric Sciences, Oregon State University. Dr. Mote will discuss the role of the Regional Integrated Sciences and Assessments (RISAs) in delivering climate services. Dr. Mote will also discuss how the RISAs interface with NOAA, other agencies, Regional Climate Centers, State climatologists, NGOs, and the private sector.

Mr. Richard J. Hirn, General Counsel and Legislative Director, National Weather Service Employees Organization. Mr. Hirn will discuss the National Weather Services' role in delivering climate service to the Nation and how these services are coordinated with other agencies, the private sector, Regional Integrated

Science and Assessments (RISAs), Regional Climate Centers, State climatologists, and NGOs.

Panel III

Dr. Michael L. Strobel, Director, National Water and Climate Center, Natural Resources Conservation Service (NRCS), United States Department of Agriculture (USDA). Dr. Strobel will discuss NRCSs role in delivering climate services and products to the Nation and how this interfaces with the services of NOAA and other agencies. Dr. Strobel will also discuss the users of the services USDA provides and how a national climate service would impact USDAs climate service.

Mr. David Behar, Deputy to the Assistant General Manager, San Francisco Public Utilities Commission and Staff Chairman, Water Utility Climate Alliance. Mr. Behar will discuss what climate services and products the San Francisco Public Utilities Commission utilizes; how these services are delivered; and how these climate services and products influence the city's operations and management decisions.

Mr. Paul Fleming, Manager, Climate and Sustainability Group, Seattle Public Utilities. Mr. Fleming will discuss how the Regional Integrated Sciences and Assessments (RISAs) deliver climate services and products to the Seattle Public Utilities, and how these climate services and products then influence their operations and management decisions.

Dr. Nolan Doesken, State Climatologist for Colorado, and Senior Research Associate, Colorado State University. Dr. Doesken will discuss the climate services and products produced at State climate offices and explain who uses this information. He will also discuss the State climate offices' relationship with the Regional Climate Centers, the Regional Integrated Sciences and Assessment (RISA) program, and the NOAA Climate Program office.

Background

Multiple actors in society, from individuals to businesses to the government, rely on weather and climate information to make decisions. The United States recognized that a well-functioning society needed this kind information and in 1890, the first law was passed to authorize the creation of a weather bureau to track the weather and provide warnings and forecasts. Since that time, our ability to monitor and forecast the weather and, therefore to understand the climate has expanded dramatically, and the need for information about weather and climate has also expanded. Satellite-based information, improvements and expansion of ground-based and ocean-based observation networks, availability of faster, more advanced computers, and improved models of climate and weather phenomenon allow the National Weather Service (NWS) to provide more accurate weather forecasts, longer lead times for severe storms, and more reliable information about fluctuations and patterns of weather over intra-annual and inter-annual, decadal and longer time scales—or climate.

Weather is the short-term variation in the state of the atmosphere that occurs in periods from minutes to weeks at specific locations. It results from the combination of temperature, humidity, precipitation, cloud cover, visibility and wind speed. Climate is the average weather conditions for a location over a period of decades (30 years, commonly) plus statistics of weather extremes.

Over these decadal periods, scientists look for patterns of variability and cycles in climate. One of the best known cycles is associated with shifts in the winds and ocean temperatures in the equatorial Pacific Ocean that result in the El Niño and La Niña cycles. Climate change is discussed in the context of years, decades or centuries. Cycles of variability are monitored and studied to determine possible shifts in long-term climate that are more permanent.

Increasing impacts of a changing climate demonstrate the need for information to support adaptation decisions. Climate variability and change are important for a wide range of human activities and natural ecosystems. Federal resource managers, State, local, and tribal governments, and the private sectors all recognize that a changing climate greatly impacts their ability to plan for tomorrow.

The National Oceanic and Atmospheric Administration (NOAA) is the leading provider of weather and climate information to the Nation and the world. Climate sciences have made major advances during the last two decades. NOAA has begun to extend climate science to address decision-relevant questions and build capacity to anticipate, plan, and adapt to climate variability and change. NOAA is providing

climate forecasts and support for planning and management decisions by other federal agencies and by State, local and tribal governments, the private sector and the public. Through programs such as the National Integrated Drought Information System (NIDIS), NOAA is expanding its delivery of climate information. Forecasts of El Niño and La Niña cycles, production of seasonal hurricane outlooks, production of monthly wildfire outlooks, and projections of snowpack and snow-melt are all examples of climate products that different user-groups are requesting and relying upon to respond to conditions that impact a wide array of economic and social activities including agriculture, the need for emergency management resources, resource management, and projections of energy demand.

The Bush Administration announced its intention to create a National Climate Service in 2008, and requested the NOAA Science Advisory Board (SAB) examine four options for organizing a National Service. Two options focused on creating the Service at NOAA and the other two options examined other organizational structures with a NOAA role, but not a NOAA lead.

Some of the key issues going forward are: the consideration of how services will be provided at the regional, State, and local levels to all potential users of climate information; what role will NOAA play in a National Climate Service; what type of interagency structure should coordinate the development and delivery of climate services by federal agencies; what is the role of other climate service providers including State and local governments; the private sector; universities; and other non-governmental organizations.

Production and Delivery of Climate Services by NOAA

The current structure at NOAA providing climate services is essentially the same structure that provides weather forecasting services. As discussed earlier, information about climate is built upon repeated, comparable observations of the weather in a given location over time. Information about climate has also grown as the number, distribution, type and quality of observations have grown. The primary line offices at NOAA that support climate services are the National Weather Service, the National Environmental Satellite, Data and Information Service and the Office of Oceanic and Atmospheric Research. Observations and information provided by other NOAA line offices and by other federal agencies and the academic community also contributes to these efforts. The roles of each of these are described briefly below.

National Weather Service (NWS)

The National Weather Service (NWS) provides and wide array of weather and climate services every day for the U.S. and other nations in accordance with its fundamental missions to support: "the forecasting of weather, the issue of storm warnings, . . ., the distribution of meteorological information in the interests of agriculture and commerce, and the taking of such meteorological observations as may be necessary to establish and record the climatic conditions of the United States."[1]

NWS operates and maintains a network of observing stations and provides operational weather and climate services through its regional centers and the 122 Weather Forecast Offices (WFO) and the River Forecast Offices (RFO) distributed throughout the Nation. The National Center for Environmental Prediction (NCEP) develops weather and climate forecast models and tools and is responsible for transitioning new models and tools to operations. The Climate Prediction Center (CPC) provides weather and climate products that span time scales from days (e.g., six- to ten-day Outlook) to months (90-day Outlook). CPC also provides the U.S. Hazards Assessment and Drought Assessments and the El Niño and La Niña predictions.

NWS provides information to other federal agencies to support their weather and climate-related work and to private sector weather providers who develop specialized forecast products for distribution to businesses and the public. NWS also interacts with the international community through cooperative programs of the World Meteorological Organization.

National Environmental Satellite, Data and Information Service (NESDIS)

The National Environmental Satellite, Data, and Information Service (NESDIS) operate the geostationary and polar weather satellites from which we obtain a wide array of observations. NESDIS receives data from the satellites, analyzes these data, provides the accompanying metadata (i.e., supporting information that describes key characteristics of data and how they were collected), and distributes

[1] 15 U.S. Code Section 313 from the 1890 *Organic Act* establishing the National Weather Service.

data products to NWS and other NOAA line offices and non-federal users for use in weather and climate models. NESDIS provides data services and support for all of NOAA and for other federal agencies. The National Climatic Data Center provides for the long-term archiving of weather and climate data. NESDIS supports data product development to improve final weather and climate forecast products.

Office of Oceanic and Atmospheric Research (OAR)

The Office of Oceanic and Atmospheric Research (OAR) conducts the majority of NOAA's in-house research through its seven laboratories. The research is organized under three major categories: weather and air quality, climate, and ocean and coastal resources. In addition to their in-house research, many of the laboratories work collaboratively with universities and other non-governmental research organizations through formal agreements. OAR's research supports the operational missions of the other line offices at NOAA, and they work cooperatively with other federal research agencies. The advanced computational work, model development, observations, atmospheric and oceanic research done by OAR has enabled NOAA to expand the types and improve the quality of climate services they deliver.

Climate Program Office

The 1978 *National Climate Program Act* directed the Secretary of Commerce to establish a National Climate Program Office. The operation and scope of duties of this office have varied since that time. Currently, the Climate Program Office (CPO) is located in the Ocean and Atmospheric Research line office and it provides strategic guidance and oversight of the Agency's climate programs.

NOAA Partnership Programs

NOAA supports programs in partnership with other governmental and non-governmental organizations here in the U.S. and internationally that develop and deliver climate services. In addition to NOAA's in-house research done through OAR and through the other line offices, NOAA supports research through grants and cooperative agreements with universities. NOAA currently supports 21 Cooperative Institutes in 17 states. A number of these are engaged in weather and climate research (e.g., Cooperative Institute for Climate Studies—Univ. of MD; Cooperative Institute for Meteorological Satellite Studies—Univ. of WI). Some of the other organizations that are working with NOAA to develop and deliver climate services are described briefly below.

Regional Climate Centers

There are six Regional Climate Centers (RCCs) overseen by the National Climate Data Center of NESDIS. The Centers are a federal-State partnership to provide climate data and information at the State and local level. The RCCs work with NESDIS to maintain the national climate data record archive and support regional climate monitoring and applied climate research. They maintain and provide access to the Applied Climate Information System, a climate data management system that facilitates collection and dissemination of climate data. The Centers often work with the network of State climatologists to facilitate exchange of data and to develop and deliver local and regional climate services.

Regional Integrated Sciences and Assessments (RISA) Program

The Regional Integrated Sciences and Assessments (RISA) Program was established by NOAA through OAR about 10 years ago. There are nine RISA offices located throughout the country. The offices are based at universities and are designed to deliver applied research on climate to decision-makers in formats that are readily applicable to regional and local situations. They provide assessments of impacts on the transportation sector, agriculture, coastal communities and human health. Feedback on current products and requests for new products come from the stakeholder community to the RISA offices and help to shape the research agenda to deliver what is needed.

Other Federal Agency Partnerships

NOAA is the primary provider of weather and climate information for the Nation; however, there are many other federal agencies that provide climate services through their own network of field offices. The specific climate services provided are developed by these other agencies with support from NOAA. The distributed interagency system that has developed provides a wide array of services delivered at the local and regional level. However, the coordination for this system is not formalized

in a holistic way. Several examples of programs for delivering climate services by federal agencies other than NOAA are provided below.

NOAA provides information to many other federal agencies and in some cases, receives data and information from the observing equipment and stations maintained by other federal agencies. USDA's Natural Resource Conservation Service (NRCS) operates the **National Water and Climate Center** to provide support for natural resource management at the level of river basins, watersheds and farm fields. NRCS is both a recipient of information from NOAA and a provider. They collect data on snowpack and soil characteristics through the Snowpack Telemetry and Soil Climate Analysis Network that is shared with other federal agencies including NOAA. NRCS utilizes data from these sources to develop climate services tailored to the needs of their traditional constituencies.

The Joint Agricultural Weather Facility is located in the Chief Economists Office at USDA. The World Board on Agriculture and NOAA established this Facility in 1977 to monitor the weather and climate and to assess the potential impacts on the yield of major crops around the world. They provide a number of climate products including a monthly review of weather highlights, an annual crop production review, and weekly soil temperature maps.

NOAA also provides support for the National Interagency Fire Center (NIFC) in Boise, ID in cooperation with eight other agencies of USDA and the Department of Interior (DOI). The NIFC provides support to federal agencies, State and local governments and the public in the preparation and mobilization of resources to prevent and fight wildfires. The Center produces monthly and three-month seasonal trend forecasts of fire potential for the U.S. The Center holds workshops each year to develop their assessments.

Private Sector Climate Services

Private Sector weather providers play a vital role in weather and climate forecasting. Their extensive radio and television outlets are the primary source of weather and climate information for the public. Private weather providers also deliver specifically tailored forecast products to individual customers using a combination of publicly available weather and climate data from NOAA augmented with observations and information from their own networks. As in the case of current weather and climate forecasting, private sector weather providers will continue to play an important role in refining and expanding the array of climate services available to specific customers and to the public.

Chair BAIRD. Good morning and welcome. Our hearing will now come to order.

I want to thank our witnesses and my colleagues and the panel, as well as staff, and the folks, other people in the audience.

Our hearing today is on developing a National Climate Service. We will discuss the need for climate services, the type of services being delivered, and options for meeting the increased demand for climate information. As we all know, climate affects all of us every day in communities across the country. As our ability to understand and recognize climate cycles and patterns has grown, so has the demand for more climate information.

This committee passed legislation in the 107th Congress, authored by Representative Hall, to expand climate services by authorizing the National Integrated Drought Information Service, or NIDIS. Droughts have taken an increasing toll on individuals, natural resources, and businesses in recent years, and these impacts have not been confined to the Western U.S. The Southeastern U.S. has experienced persistent drought conditions that still have not been completely alleviated in all areas. The severe shortage of water drove power plants to temporary shutdown, created financial hardships for recreational businesses, and loss in crop yields for farmers.

Without some ability to predict the intensity and duration of these climatic events, State and local governments cannot develop plans to respond to them. That is why we need climate services. There are many examples where climate predictions have been useful in making important decisions. In our part of the country, the Pacific Northwest, data on snowpack provides critical information to decision-makers and water managers about the likely availability of water through the spring and summer months.

The long-term data records that we have acquired through years of monitoring the weather indicate that climate is changing. Whether you believe this is due to greenhouse gases or to natural, long-term shifts in climates, we still need to understand the phenomenon and adapt to it. Therefore, it is in our best interests to structure a service that will utilize expertise to develop information that will not only support us nationally, but at the regional and local scale, where adaptation and response plans can best be implemented.

Today, we will hear from witnesses who deliver climate services, and from those who use them. I look forward to hearing their recommendations for refining and expanding climate service to better address the needs of communities, businesses, and individuals for climate information that will reduce their vulnerability to weather and climatic events. I also look forward to hearing from the Administrator of NOAA, Dr. Lubchenco, about the Administration's plans for improving the delivery of climate services to the country. We may not be able to control the weather and climate, but we can prepare for it and adapt to it, if we know what we are facing.

With that, I look forward to the testimony we will receive today. I want to thank our witnesses, and now recognize the distinguished Ranking Member, Mr. Inglis, for his opening remarks.

[The prepared statement of Chair Baird follows:]

PREPARED STATEMENT OF CHAIR BRIAN BAIRD

Good morning and welcome to today's hearing on Developing a National Climate Service. Today we will discuss the need for climate services, the type of services being delivered, and options for meeting the increased demand for climate information.

Climate affects all of us everyday in communities across the country. As our ability to understand and recognize climate cycles and patterns has grown, so has the demand for more climate information. This committee passed legislation in the 107th Congress authored by Representative Hall to expand climate services by authorizing the National Integrated Drought Information Service or NIDIS.

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I also look forward to hearing from the Administrator of NOAA, Dr. Lubchenco, about the Administration's plans for improving the delivery of climate services to the country.

We cannot control the weather and climate, but we can prepare for it and adapt to it if we know what we are facing.

With that, I look forward to the testimony we are going to receive today. I want to thank all of our witnesses for participating in this important hearing. I now recognize our distinguished Ranking Member Mr. Inglis for his opening remarks.

Mr. INGLIS. Thank you, Mr. Chairman. Thank you for holding this hearing.

While Congress continues to debate the right way to reduce our greenhouse gas emissions and limit future anthropogenic changes to our climate, farmers, water managers, land use planners, and other decision-makers are trying to plan for the impacts of climate change that we can expect over the next few decades.

We have a lot of work to do to provide them with the information they need. NOAA has done a good job of identifying existing capabilities and launching the process of constructing a National Climate Service at the federal level. In addition, the Science Advisory Board's Report, *"Options for Developing a National Climate Service,"* highlight the challenge of coordinating the unique roles of several federal agencies.

I am interested in learning more about how we can marry federal services with research universities and State climatology offices, to keep the focus on local users. Existing climate information services aim to provide tools for seasonal and yearly planning. In South

Carolina, we use this information to decide what crops to plant, how to manage our water supply, and whether we can expect forest fires, like the ones that raged on our coast last month.

The testimony we are going to hear today highlights the critical importance of this information. The challenge is also expanding services and provide accurate information to a wide variety of users, for both short- and long-term decision-making. We also need to have a serious discussion about resources at NOAA. Existing observation and monitoring networks need to be updated. Computing capabilities are insufficient for local modeling, and information delivery needs to be improved to get the right information to the right people.

These efforts won't be inexpensive, and we need to identify those needs now.

Thank you again, Mr. Chairman, for holding this hearing, and thank you to the witnesses for appearing here. I look forward to learning about our progress toward a National Climate Service, and what obstacles remain.

[The prepared statement of Mr. Inglis follows:]

PREPARED STATEMENT OF REPRESENTATIVE BOB INGLIS

Good morning and thank you for holding this hearing, Mr. Chairman.

While Congress continues to debate the right way to reduce our greenhouse gas emissions and limit future anthropogenic changes to our climate, farmers, water managers, land use planners, and other decision-makers are trying to plan for the impacts of climate change that we can expect over the next few decades. We have a lot of work to do to provide them with the information they need.

NOAA has done a good job of identifying existing capabilities and launching the process of constructing a National Climate Service at the federal level. In addition, the Science Advisory Board's report, *Options for Developing a National Climate Service,* highlights the challenge of coordinating the unique roles of several federal agencies. I'm interested in learning more about how we can marry federal services with research universities and State climatology offices to keep the focus on local users.

Existing climate information services aim to provide tools for seasonal and yearly planning. In South Carolina, we use this information to decide what crops to plant, how to manage our water supply, and whether we can expect forest fires like the one that raged on the coast last month. Mr. Fleming, your testimony highlights the critical importance of this information. The challenge is to expand these services and provide accurate information to a wide variety of users for both short- and long-term decision-making.

We also need to have a serious discussion about resources at NOAA. Existing observation and monitoring networks need to be updated, computing capabilities are insufficient for local modeling, and information delivery needs to be improved to get the right information to the right people. These efforts won't be inexpensive and we need to identify those needs now.

Thank you again, Mr. Chairman, and thank you to the witnesses. I look forward to learning about our progress to a National Climate Service and what obstacles remain.

Chair BAIRD. I thank you, Mr. Inglis.

[The prepared statement of Mr. Costello follows:]

PREPARED STATEMENT OF REPRESENTATIVE JERRY F. COSTELLO

Good Morning. Thank you, Mr. Chairman, for holding today's hearing on the development of a National Climate Service.

Among the many challenges posed by climate change, one of the most important to address will be how these changes will impact our resources. Without workable information about the impacts of climate change, I am concerned our farms and industries will be unable to plan for the future.

Currently, a variety of NOAA offices and programs make and distribute predictions about climate changes for a range of customers. Should Congress choose to

develop a National Climate Service, the new program would need to be coordinated and efficient. Congress should work with NOAA and other stakeholders to ensure that this national service is quickly developed and works with the programs already in place. I am interested to hear from Dr. Lubchenco what she believes will be the most efficient means of consolidating and streamlining our current programs into a National Climate Service.

It also will be important for a National Climate Service to provide useful, workable information to a variety of customers in different regions and different industries across the country. I am interested in hearing from the current providers of climate predictions on how a coordinated National Climate Service will enhance the programs currently in place. I would also be interested to hear their recommendations for streamlining the current system without diminishing or cutting back current programs. Finally, I am interested to hear from the utility companies how Congress and this subcommittee can best develop a program that suits your needs and continues to provide necessary information.

I welcome our panel of witnesses, and I look forward to their testimony.

Panel I

Chair BAIRD. It is really a pleasure now to be able to introduce Dr. Jane Lubchenco at her first visit to this committee. I am sure it will be the first of many to come, and I thank you very much for your time.

New Administrators are—Administrators are always busy, but especially at the start of a new Administration, and we would very much respect your time. But I do want to take the time for my colleagues and for members of the audience and others to be aware of just how impressive the resume of our new Director of NOAA is.

Dr. Jane Lubchenco, a marine ecologist and environmental scientist, is the ninth Administrator of NOAA. Her scientific expertise includes oceans, climate change, and interactions between the environment and human wellbeing. Raised in Denver, she received a B.A. in biology from Colorado College, an M.S. in zoology from the University of Washington, and a Ph.D. in ecology from Harvard University. While teaching at Harvard from 1975 to '77 and Oregon State from '77 to 2009, she was actively engaged in discovery, synthesis, communication, and application of scientific knowledge. Dr. Lubchenco has studied marine ecosystems around the world, and championed the importance of science and its relevance to policymaking and human well-being.

A former President of the American Association for Advancement of Science, the International Council for Science, and the Ecological Society of America, she served ten years on the National Science Board, which this committee knows is basically the Board of Directors for NSF. From 1999 to 2009, she led a large four university interdisciplinary team of scientists, investigating the large marine ecosystems along the coast of Washington, Oregon, and California. She has a special interest in arctic ecosystems.

Her scientific contributions include eight publications which are considered science citation classics. She is one of the most highly cited ecologists in the world. She is an elected member of the National Academies of Sciences, the American Academy of Arts and Sciences, the American Philosophical Society, and the Royal Society. She has received numerous awards, including a MacArthur Genius Fellowship. Why don't we ever get—no, don't answer that question. Nine honorary degrees, the 2002 Heinz Award in Environment, the 2005 AAAS Award for Public Understanding of

Science and Technology, the 2008 Zayed International Prize for the Environment. She has also served on the Pew Oceans Commission and the Joint Oceans Commission Initiative, and the Aspen Institute Arctic Commission. Clearly someone who is totally unqualified for the position. Remarkable resume, the latter was a joke.

This is an extraordinarily well qualified, impressive individual. We are grateful for your time and your expertise, and in respect for that time, and the various demands, I have asked that you be solo up today, so we can move quickly through what you have to say and our questions, and then, we will recognize other panels as follows.

So, with that, as witnesses should know, we will have five minutes for your spoken testimony. We have received your written testimony, and then, following your testimony, Dr. Lubchenco, we will alternate between the two sides.

Thank you, and please begin.

STATEMENT OF DR. JANE LUBCHENCO, UNDER SECRETARY OF COMMERCE FOR OCEANS AND ATMOSPHERE; ADMINISTRATOR, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)

Dr. LUBCHENCO. There we go. Is that on? Thank you, Chairman Baird, Ranking Member Inglis. It is indeed a great pleasure for me to be here, and I too look forward to strong, productive, ongoing interactions with the Subcommittee and the Full Committee. So, thank you for your warm welcome.

I am here today to discuss some of the benefits of the National Climate Service, and what it could provide to the Nation, as we work to adapt to a changing climate. I will also share with you our vision for how NOAA will work with other government agencies, the Executive Office of the President, and a diversity of public and private sector partners to help shape the National Climate Service, one that builds on existing capabilities, but also leverages the capacities of a range of federal agencies and other partners to develop new and vitally useful information services and delivery mechanisms.

The Nation has already benefited from a sustained federal and extramural partnership and collaborations aimed at documenting and understanding climate change. Federal interagency collaborations, such as the climate change research efforts of the U.S. Climate Change Science Program and the U.S. Global Change Research Program, have produced state-of-the-art guidance through 21 synthesis and assessment products in the forthcoming *"State of Knowledge Report on Global Climate Change Impacts in the U.S."*

We are indeed very proud of these achievements. Reports like these do an outstanding job of synthesizing existing scientific information. They do not, however, even begin to deliver all of the guidance now being sought by decision-makers from private and public sectors from local to international levels. To fill this void, a number of efforts have arisen to provide some climate services, and you will hear about many of those today.

Each of these is important, but collectively, they are insufficient to meet the growing demand. More work and better integrated mechanisms are needed to provide usable, credible, salient infor-

mation on an ongoing basis. In particular, more work is needed to understand users' needs, and to deliver climate relevant information at the appropriate scale in a fashion that is both true to the scientific knowledge, but also, sensitive to users' diverse styles and needs.

Just as the Nation's climate research efforts have required sustained federal agency partnerships and strong engagement of academic and other partners, a new effort to provide climate services will also require sustained federal agency partnerships and collaboration with climate service providers and end users. It is time to learn from and build on existing efforts, but to take them to a new level of usability and usefulness.

There is unequivocal evidence that the Earth is warming. This warming can be seen in increases in global average surface air and ocean temperatures, widespread melting of snow and ice, rising sea levels, and changes in many other climate-related variables and impacts. The impacts of our changing climate are regionally diverse, and relevant across numerous sectors, including water, transportation, forestry, coasts, fisheries, and human health.

These impacts are expected to grow in response to projected future climate change. Weather and climate have profound impacts on our nation's economic and social well-being. Drought alone is estimated to result in average annual losses of between $6 and $8 billion to all sectors of the economy, including transportation, agriculture, and energy.

The Nation's systems and infrastructure for water, energy, transportation, agriculture, and other sectors, have been designed and built based on what we know about current local environmental conditions or our understanding of the recent past. The assumption has been that the past will be a good indicator of the future. In similar fashion, our approaches to the management and conservation of ecosystems and species have been based on current and recent climate conditions.

But now, the background patterns of temperature, rainfall, snowfall, and more are changing. For example, in the Northeast U.S., the number of heaviest precipitation days, defined as the heaviest one percent of all precipitation events, has increased by a startling 58 percent since 1958. Throughout the country, rapid climate change is presenting new challenges for managing water, building in coastal zones, growing food, providing clean energy, and helping to keep Americans healthy.

As a consequence, decision-makers at all levels of government are seeking information to help them prepare their communities for the impacts. In similar fashion, the private sector is hungry for similar information to guide their planning. It is increasingly clear that the Nation needs an objective, authoritative, and consistent source of consolidated, reliable, and timely climate information at the appropriate scale to guide decision-making. This concept of the National Climate Service as a single point of accountability has been studied by the National Academy of Sciences, external advisory groups, and others. Each of these reports has raised serious issues, and has caused our thinking about a climate service to evolve.

The overarching goal of a National Climate Service would be to provide the essential information about climate change that is needed for effective decision-making. A National Climate Service would enable public and private sector decision-makers, resource managers, and the public to better anticipate, plan, and respond to impacts of changing climate conditions. A National Climate Service would build on many agencies and other organizations' strengths and expertise, and rely upon strong partnerships across all levels of government, academia, and the private sector.

Because NOAA already provides many climate services and data, because it has recognized scientific leaders with climate expertise, and because it has considerable experience in providing a range of other services, NOAA is well positioned and ready to work with a range of partners to help lead the development of a National Climate Service.

The scientific basis for evaluation of climate change and its impacts must continue to come from existing collaborative efforts, with the relevant leading agencies, including NOAA, DOE, NASA, EPA, DOI, and NSF. These agencies will provide much of the data, information, and knowledge that will support a National Climate Service. The pace and nature of changes in Earth's climate reinforce the need for delivering targeted climate services. Much work lies ahead of us. We will need to draw from the experience of all of our partners to support the development of science-based and user-driven climate services.

NOAA will contribute to this effort by building on its existing capacities and partnerships and networks to deliver and evolving suite of climate information and services, in collaboration with our partners.

We are prepared to provide the leadership in partnership with other federal agencies to the design and development of a National Climate Service. Through an interactive dialog that engages the breadth of climate service providers and interests, including providers, researchers, and users.

I look forward to working with the Committee, the White House Office of Science and Technology Policy, other federal agencies, and our partners to further evaluate and design the merits of the this effort.

Thank you very much for the opportunity to testify, and I am happy to answer any questions.

[The prepared statement of Dr. Lubchenco follows:]

PREPARED STATEMENT OF JANE LUBCHENCO

Introduction

Chairman Baird, Ranking Member Inglis, and other Members of the Subcommittee, I am pleased to speak with you today regarding the need for a National Climate Service and I am honored to be here as the Under Secretary of Commerce for Oceans and Atmosphere and the Administrator of the National Oceanic and Atmospheric Administration (NOAA), one of the Nation's premiere science and stewardship agencies, to discuss NOAA's capabilities in supporting this evolving national need.

The climate challenge before us is real. Through sustained federal and extramural partnerships and collaboration, the Nation has made significant progress in our understanding of climate change. One example of federal agency accomplishments realized through such collaborations is the climate change research efforts of the U.S. Global Change Research Program and the U.S. Climate Change Science Program. The sustained partnerships and collaborations established through this intergovern-

mental body resulted in the publication of 21 synthesis and assessment products, and the forthcoming report on *Global Climate Change Impacts in the United States.* This report will provide a comprehensive survey of the state of knowledge about climate change impacts in the United States, and will highlight for the American public just how far we have come in our understanding of climate change. We are proud of this achievement.

More work is needed, however, to understand users' needs and deliver climate-relevant information to inform decision-making. In 2007, The National Academy of Sciences released *Evaluating Progress of the U.S. Climate Change Science Program: Methods and Preliminary Results,* which highlighted existing gaps in federal programs to provide climate change information. This report recognized that good progress has been made to determine many aspects of climate change however, "progress in synthesizing research results or supporting decision-making and risk management has been inadequate."

Just as the Nation's climate research efforts require and benefit from interagency and academic partnerships, so too will the communication of climate information to users. No single agency is capable of providing all of the information and services needed to inform decision-making. To be successful, this effort too will require sustained federal agency partnerships and collaboration with climate service providers and end-users.

Today, I am here to discuss with you some of the benefits that a National Climate Service could provide as the Nation works to adapt to our changing climate. I will also share with you our vision for how NOAA will work with the several other relevant government agencies, the Executive Office of the President, and a diversity of public and private sector partners, to help shape a national effort that builds on existing capabilities and leverage the capabilities of other federal agencies to develop new information, services and delivery mechanisms to realize the potential of such a Service.

THE EARTH'S CLIMATE IS CHANGING

There is unequivocal evidence that the Earth is warming. This warming can be seen in increases in global-average surface air and ocean temperatures, widespread melting of snow and ice, rising sea level, and changes in many other climate-related variables and impacts.[1] Most of the observed increases in global temperatures since the mid-20th century are very likely due to human-induced emissions of greenhouse gases.[1]

Under a broad range of non-mitigation scenarios considered by the Intergovernmental Panel on Climate Change, warming over this century is projected to be substantially larger than over the past century. Changes in many other components of the climate system (warming patterns being only one example) are also very likely to be larger than those observed in the present century. The prospects of such climate changes have profound implications for a global society, underscoring the need for scientific information to aid decision-makers in developing and evaluating options for mitigating future anthropogenic climate change as well as alternatives for adapting to a changing climate.

Within the United States, extensive climate-related changes have been documented over the last century. These include increases in continental-average temperatures, rising sea levels in many coastal locations, an increased frequency of extreme heavy rainfall events, lengthening of the growing season, earlier snow-melt, and altered river flow volumes. Water is an issue in every region, but the nature of the potential impact varies. Drought is a serious problem in many regions, especially in the West and Southeast; and floods and water quality problems are likely to be amplified by climate change in most regions.

For example, the amount of rain falling in the heaviest downpours has increased approximately 20 percent on average in the past century, and this trend is very likely to continue, with the largest increases in the wettest places. Many types of extreme weather events, such as heat waves and regional droughts, have become more frequent and intense during the past 40 to 50 years.

As a nation, our economic and social well-being is intricately tied to weather and climate; this relationship produces significant social and economic benefits and costs. Some examples include:

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[1] IPCC, 2007: *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, Pachauri, R.K. and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.

- Coral reefs world wide are among the ecosystems of highest risk of extreme degradation due to climate change. In 2002, Hawaii's coral reefs, when combining recreational, amenity, fishery, and bio-diversity values, were estimated to have direct economic benefits of $360 million/year.[2]
- Drought is estimated to result in average annual losses to all sectors of the economy of between $6–8 billion.[3,4]
- Average annual damage from tornadoes, hurricanes, and floods is $11.4 billion, of which:
  - hurricanes average $5.1 billion and 20 deaths per year;
  - floods account for $5.2 billion, and average over 80 deaths per year, and
  - tornadoes cause $1.1 billion in damages.[5]

These examples of current weather and climate impacts are why the future effects of climate change matter.

HOW COULD THE NATION BENEFIT FROM A NATIONAL CLIMATE SERVICE (NCS)?

The impacts of our changing climate are regionally diverse and relevant across numerous sectors, including water, energy, transportation, forestry, coasts, fisheries, agriculture, ecosystems, and human health. These impacts are anticipated to grow in response to projected future climate change.

Until now, the systems and infrastructure that we as a nation have developed as the foundation of our water, energy, transportation, agriculture, and other sectors have been designed and built based on what we know about local environmental conditions, and our understanding of the past. In the same way, our approaches to the management and conservation of ecosystems and species have largely relied upon our scientific, historical understanding of those systems.

For example, water planning and management have been based on historical fluctuations in records of streamflows, lake levels, precipitation, temperature, and water demands. All aspects of water management including reservoir sizing, reservoir flood operations, maximum urban storm water runoff amounts, and projected water demands have been based on these records. Because climate change will significantly modify aspects of the water cycle, the assumption of an unchanging climate is no longer appropriate for many aspects of water planning. To appropriately prepare their communities, decision-makers will need to be supported with access to the best climate information science can provide, and tools to apply that data to guide their decisions.

Meeting the climate challenge will require an unprecedented level of coordination among federal agencies, along with our nongovernmental partners, to pull together our collective expertise to accomplish the goal of providing high quality climate information and services that are user-friendly, responsive, and relevant. A broad range of capabilities for providing climate information currently exists in federal agencies, and various other organizations. As we move forward we must find ways to maximize use of these capabilities, by integrating efforts to provide climate information and services that most effectively and efficiently respond to user needs.

The Nation's need for user-driven climate services is increasing and the Federal Government recognizes the importance of responding to these increasing demands. In order to ensure climate information and services are available to meet current and anticipated demands, many scientific agencies, including NOAA, the Department of Energy (DOE), the Department of the Interior (DOI), the Environmental Protection Agency (EPA), the National Science Foundation (NSF), and the National Aeronautics and Space Administration (NASA), will continue climate research activities to provide the valuable data required to understand how our climate is

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[2] Cesar, H., P. van Beukering, S. Pintz, and J. Dierking, 2002: *Economic valuation of Hawaiian reefs.* Cesar Environment Economics Consulting, Arnham, The Netherlands, 123 pp.

[3] Economic Impacts of Drought and the Benefits of NOAA's Drought Forecasting Services, *NOAA Magazine,* September 17, 2002.

[4] Interagency Working Group on Earth Observations, National Science and Technology Council Committee on Environment and Natural Resources. (2005) *Strategic Plan for the U.S. Integrated Earth Observation System.*

[5] National Center for Atmospheric Research (NCAR), Environmental and Societal Impacts Group, and the Atmospheric Policy Program of the American Meteorological Society. (2001) *Extreme Weather Sourcebook 2001: Economic and Other Societal Impacts Related to Hurricanes, Floods, Tornadoes, Lightning, and Other U.S. Weather Phenomena,* National Center for Atmospheric Research, Boulder, Colo. Available only online at *http://sciencepolicy.colorado.edu/sourcebook/data.html*

changing. The contributions of these agencies are coordinated by the National Science and Technology Council through its Subgroup on Global Change Research.

At a hearing this committee held in May 2007, the Western Governors Association stated that "decision-makers at all levels of government and in the private sector need reliable and timely information to understand the possible impacts and corresponding vulnerabilities that are posed by climate change so that they can plan and respond accordingly."

Specific examples of requests for climate services include the following:

- The wind power industry has identified a need for baseline data and future projections of wind measurements that would aid them in long-term planning for wind energy development to ensure a return on their investment.

  Corn growers have requested regional and long-term climate forecasts that would help them in making decisions about when and what they should grow.
- Federal agencies with land and water management mandates, such as the Bureau of Reclamation and the U.S. Army Corp of Engineers, have requested scientific information and technical training on climate change impacts.

Around the country, decision-makers at all levels of government are considering options for how to best prepare their communities for the impacts of a changing climate. As we move forward with efforts to mitigate and adapt to our changing climate, we will need to draw from the expertise of all federal agencies engaged in climate change science to support the development of climate services to enable decision-making. The Nation needs an objective, authoritative, and consistent source of consolidated, reliable, and timely climate information to support decision-making.

As I mentioned during my confirmation hearing, I believe our country must address the impacts of the changing climate head-on. In my work on the Pew Ocean Commission, I heard first-hand from businesses and State and local governments in communities all across this country about the need for reliable information and predictions about the impacts of climate change. From concerns about droughts and sea level rise to changes in the chemistry of the ocean, there is a real hunger for more and better information. NOAA is equipped, and ready to work with its partners, to provide this information.

KEY COMPONENTS OF A NATIONAL CLIMATE SERVICE

Unlike climate services, weather services are familiar to most citizens. Weather services focus on the description, analysis, and atmospheric forecasting on very short time scales, from minutes extending up to a period of one week to ten days. The objective is to provide forecasts of continually changing weather conditions and warnings of severe weather events to protect life and property. The benefits of this service are measured in lives saved, injuries avoided, and reduction in property damage.[6] For example, through NOAA's hurricane research to operations efforts, NOAA has improved wind speed estimates by 15 percent since 2004 and reduced track forecast error by 50 percent since 1990. These hurricane forecast improvements are estimated to save taxpayers $640,000 per non-evacuated mile.

In contrast to weather, climate refers to the longer-term statistical properties of the atmosphere-ocean-ice-land system. Climate variability and change are products of: (1) external factors, such as the sun; (2) complex interactions involving the different components of the Earth system; and (3) human-induced changes to the Earth system. Climate services encompass a variety of types of activities in order to address the range of short- to long-term variations and changes in climate, including those that are natural and human induced. Such activities are often associated with different types of users or decision-makers and with different types of needs and products.[6] Improving development and targeting delivery of climate information through a National Climate Service offers untold economic, public health and safety, and national security benefits.

NOAA has a vision of a National Climate Service as a partnership that would be established with other federal agencies, various levels of government, and the private sector. The National Climate Service would provide credible and authoritative climate information and services to assist the Nation, and by extension the world. This would include policy-relevant information for decisions related to climate change mitigation and adaptation. This concept of developing a National Climate Service as a single point of accountability for providing climate information and services to the Nation has been studied by NOAA, the National Academy of

[6] Board on Atmospheric Sciences and Climate, National Research Council (2001) *A Climate Services Vision: First Steps Toward the Future.*

Sciences,[7] external advisory groups, and by Members of this committee. Each of these studies has raised important issues that will need to be addressed. NOAA's current vision for a National Climate Service has evolved as a direct result of these studies, as well as input and feedback from public and private sector partners and constituents around the Nation.

The overarching goal of a National Climate Service would be to provide the essential climate change information needed for effective decision-making. As such, a National Climate Service must enable decision-makers, including resource managers, and the public to better anticipate, plan, and respond to impacts of changing climate conditions. A National Climate Service must also remain engaged in climate change science to maintain credibility, awareness, and flexibility, and to avoid insularity. In similar fashion, the National Climate Service must engage with a diversity of users to fully understand the needs and provide salient and usable information, tools, and expertise.

The National Climate Service will build on many agencies' strengths and experience. The scientific basis for evaluation of climate change and climate change impacts on a global and regional level will come from existing collaborative efforts underway among NOAA and the other leading climate research agencies, including DOE, DOI, EPA, NASA, and NSF, in the following areas:

- climate observing systems and effective data management and delivery systems;
- problem-focused research and a close coupling with fundamental climate change research that establishes scientific credibility of evolving products;
- climate modeling for predictions and projections; and
- local, regional, national, and international assessments of climate change.

Working with its partners, the National Climate Service will help support the following core climate services:

- ongoing, deliberate dialogue with users to understand evolving needs,
- climate tools and other products at scales relevant to support user decision-making;
- user outreach and capacity building; and
- public understanding.

In order to build and maintain a bridge linking information and users, the Service will provide information to meet the key needs of government and society. Some of these products and services will be relevant for relatively short-term adaptation and mitigation decision support; others will be tailored to be relevant for longer-term choices. Some will be operational in nature; others will inform assessments of the state of climate research.

The National Climate Service must have a clear set of principles regarding its products and services to ensure that it remains appropriately focused and managed in an effective way that best serves the Nation. NOAA envisions a successful Service guided by the following principles:

- provide balanced, credible, cutting edge scientific and technical information;
- focus on human-caused climate change, but link human-caused climate change and changes in natural variability, such as the frequency and duration of droughts, to meet broad user needs;
- provide and contribute to science-based products and services to minimize climate-related risks;
- provide predictions and projections of climate at scales relevant to decision support;
- strengthen observations, standards, and data stewardship;
- ensure timely assessments;
- improve regional and local projections of climate change;
- inform policy options;
- inform decisions and management options of others;
- foster climate literacy and workforce development; and

[7] National Research Council, Panel on Strategies and Methods for Climate-Related Decision Support, Committee on Human Dimensions of Global Change (2009) *Informing Decision in a Changing Climate.*

- engage a diversity of users in meaningful ways to ensure their needs are being met.

An effective response to the societal demands of a changing climate is well beyond the scope, authority, or mission of any one federal agency. NOAA commissioned an external review of the challenge of developing a National Climate Service. This external review recommended each federal agency collaboratively define its role and level of commitment in a National Climate Service, but made clear that there must be a lead federal entity. This view is further endorsed by a recent report by the National Research Council,[8] which stated: "Because successful programs have a leader (NRC, 2005),[9] the committee recommends that one agency take the lead in developing the climate service, although multiple agencies would have to be involved in its design and implementation." With respect to implementation, a more recent report by the National Research Council[10] notes ". . . that (the panel) does not recommend centralizing the initiative in a single agency," reflecting on the importance of integrating research and service functions across multiple agencies. NOAA agrees with these recommendations and is ready to meet the challenge of helping lead the development of a National Climate Service and working with our partners in its implementation to provide targeted climate information to the public and private sector to inform decision-making.

An effective National Climate Service will rely upon strong partnerships within and among federal agencies, and across levels of government, academia and the private sector to provide the Nation with the science-based and user-responsive climate services it needs. This vision also requires that NOAA integrate its own resources and coordinate efforts with its partners to ensure reliable delivery of climate services and information.

As I've stated earlier, no single agency can address the climate challenge on its own. NOAA is well positioned to provide leadership for a National Climate Service, based on the climate research efforts and experience in providing user-centric services of the collective Federal Government and nongovernmental partners. NOAA will continue to work with our interagency partners and most especially the agencies that participate with us as part of the U.S. Climate Change Science Program. These agencies will provide much of the data and information that will support the delivery of climate services, and include: the Departments of Agriculture, Defense, Energy, Health and Human Services, the Interior, State, and Transportation; together with the Environmental Protection Agency, the National Aeronautics and Space Administration, the National Science Foundation, the Agency for International Development, and the Smithsonian Institution, and overseen by the Office of Science and Technology Policy, the Council on Environmental Quality, the National Economic Council and the Office of Management and Budget.

Further design of a National Climate Service must be based on an interactive process that engages federal agencies and individuals from across the spectrum of climate research, service provision, users, partners and stakeholders. This process must be interdisciplinary, user-focused, regionally-representative, and include analysis of strengths and gaps in capacities. A critical design consideration that must be addressed in these processes is the best arrangement for federal agencies to work in partnership to maximize delivery of climate services to the Nation. As such, it would be appropriate for the White House Office of Science and Technology Policy (OSTP) to lead an interagency process to analyze capacities and options. This effort would complement the broader interagency effort being led by the Council on Environmental Quality, OSTP and NOAA to prepare a federal adaptation strategy to help the Federal Government, along with State, local and private actors, increase their resilience to a changing climate.

The public-private partnership that makes today's National Weather Service so successful provides a useful model to emulate. The Federal Government would not be able to fully provide critical information to the Nation without the private sector. We envision the government will develop and maintain an infrastructure of observation and information services on which the public (Federal, State, and local governments), private, and academic sectors will rely. The private sector will be able to use data collected by this infrastructure to create unique products and services tailored to the needs of their company or clients. We believe this cooperative relation-

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[8] National Research Council (2009) *Restructuring Federal Climate Research to Meet the Challenges of Climate Change.*

[9] National Research Council (2005) *Thinking Strategically.*

[10] National Research Council, Panel on Strategies and Methods for Climate-Related Decision Support, Committee on Human Dimensions of Global Change (2009) *Informing Decision in a Changing Climate.*

ship will lead to an extensive and flourishing set of climate services that will be of great benefit to the U.S. public and to major sectors of the U.S. economy.

Finally, addressing the evolving climate challenge will require supporting decision-makers not just for a few years, but over many decades. The National Climate Service must be highly-responsive to changing user needs and able to lead based upon expert evaluation of new data and knowledge. The scope and nature of user interactions and partnerships required to support this effort will demand an extraordinary investment in ensuring continuous feedback and adaptive learning among users and providers. Similarly, products and services must be able to evolve, and be initiated rapidly, in response to new scientific information. These complex characteristics and relationships will necessitate ongoing assessments and evaluations of progress, plans, user requirements, and outcomes as a core component of an adaptively-managed National Climate Service.

FROM NOAA'S CURRENT CLIMATE CAPABILITIES TO A NATIONAL CLIMATE SERVICE

There is much work to be done to fully realize a National Climate Service. The development of a National Climate Service will take leadership and sustained efforts across the Federal Government to work collaboratively. Through its climate research and science, NOAA is currently delivering climate services that generate significant social, economic, and environmental benefits for the Nation. These services are outlined below, as requested by the Committee in my letter of invitation, and represent some of the contributions that NOAA would bring to a National Climate Services.

NOAA's current climate and climate-related capabilities and mandates

NOAA's mission is to understand and predict changes in Earth's environment and conserve and manage coastal and marine resources to meet our nation's economic, social, and environmental needs. This mission already encompasses the delivery of some climate services. As the lead federal agency responsible for delivering national weather, ocean, fishery, coastal, and environmental data products and services, and among the leaders in climate and satellite information, NOAA provides some of the many scientific underpinnings required for an effective National Climate Service.

The breadth of NOAA's climate and climate-related capabilities includes:

- A long history of building sustained partnerships and interacting with other federal agencies, the private sector, all levels of government (international, national, State, tribal, local), non-governmental organizations, and the public.
- Extensive experience in both weather and climate forecasts and predictions. Weather forecasts, seasonal outlooks, inter-annual to decadal predictions, and climate change projections require observations, models, and scientific understanding of the Earth system. NOAA has established a strong and sustained capability and infrastructure in all of these areas.
- Existing strengths in climate and earth system research and modeling. NOAA maintains a range of capabilities to understand and address key impacts of climate such as coastal hazards, ocean acidification, droughts and floods.
- At an international level, NOAA along with other leading climate research agencies has played a major role in informing policy decisions by contributing to scientific assessments including the World Meteorological Organization/ United Nations Environment Programme Scientific Assessments of Ozone Depletion and the Intergovernmental Panel on Climate Change assessment reports. NOAA has served as one of the lead agencies of the U.S. Climate Change Science Program (CCSP) and had a primary role in its predecessor, the U.S. Global Change Research Program. NOAA has led several of the CCSP synthesis and assessment products, including the forthcoming report on *Global Climate Change Impacts in the United States.*
- A unique breadth of mandates and experience in environmental service delivery that provide a strong foundation for a National Climate Service. NOAA's mandated responsibilities include, for example: fisheries, endangered species and marine mammal management, National Marine Sanctuaries, and coastal and estuarine management. With each of these mandates, NOAA managers must account for the effects of climate variability and change on coastal and marine ecosystems, and resources and communities, as well as adapt their management practices accordingly. NOAA and its partners in coastal and marine resource managers are among the vanguard of users of climate information. In addition, the National Weather Service has an established and cred-

ible field infrastructure that currently delivers climate products daily at a national, regional, and local level.

- NOAA contributes to sustained climate observing networks comprised of a suite of operational satellites and *in situ* networks for integrated atmospheric and oceanic observations, including measurements of air and ocean temperatures, greenhouse gases, aerosols, and ozone. NOAA also maintains several of the Nation's permanent archives of weather, climate, and oceanographic data through its data centers. NOAA, along with the other leading climate research agencies, provides analyses of the observed records, including the Nation's climate statistics and reanalysis of observations for initial conditions for climate prediction. With its wealth of observational data, NOAA makes major contributions to the process studies required to attribute the causes of climate change.

Transitioning to a National Climate Service

Through our existing statutory responsibilities under the *National Climate Program Act of 1978* (15 U.S.C. §§ 2901–2908), NOAA has a long history of producing climate information, delivering products and services, and building the capacity of others through established networks and partnerships at all levels.

We expect that development of a National Climate Service will stimulate advancements of similar stature as those generated through NOAA's integrated weather services. For example, NOAA's 'end to end' weather services have increased annual average lead times for tornadoes from less than four minutes in 1987 to almost 15 minutes today, and flash floods from less than 10 minutes in 1987 to better than 50 minutes today. Such advancements are estimated to have contributed to NOAA's weather services preventing over 330 fatalities and 7800 injuries from tornadoes, and to have resulted in health and welfare benefits that we estimate to be of over $3 billion between 1992 and 2004.

Development of a National Climate Service can benefit from NOAA's existing expertise, infrastructure, and capabilities in climate science; its extensive experience in service delivery; its relationships with other federal, State, and local partners; and must leverage the extensive experience of the other leading climate research agencies. NOAA's existing climate products and services include climate data services, climate predictions and climate change projections, assessments, and decision support information.

Existing networks include interagency and other partnerships that comprise the National Integrated Drought Information System (NIDIS), National Weather Service Forecast Offices and River Forecast Centers, National Data Centers, Regional Integrated Science and Assessment projects at universities, Regional Climate Centers, State Climatologists, Sea Grant, the Coastal Services Center, international climate research institutes, NOAA Cooperative Institutes, and extension agents.

Two examples illustrate NOAA's experience as a leading source of climate information and provide a strong indication of the agency's foundation for the development of climate services: (1) NOAA's partnership with the National Association of Home Builders and Department of Housing and Urban Development, and (2) its leadership of NIDIS.

Partnership with the National Association of Home Builders and the Department of Housing and Urban Development (HUD)—NOAA performed a decade of research to develop an Air Freezing Index, which has now translated into operational use by the construction industry. Home builders can now construct a frost protected shallow foundation as a practical alternative to deeper, more-costly foundations in cold regions with seasonal ground freezing and the potential for frost heave. Construction of a frost protected shallow foundation can be informed by NOAA's Air Freezing Index, and incorporates strategically placed insulation to raise the frost depth around a building. NOAA's air freezing research is estimated to provide an annual savings benefit to U.S. homeowners of $300 million saved in new construction costs and energy savings of 586,000 megawatt-hours.

National Integrated Drought Information System (NIDIS)—The growing impacts of drought on society led to a call by our State governors for drought preparedness information. NOAA's implementation of the *NIDIS Act of 2006* is being achieved through the coordination and collaboration of federal, State, tribal, academic, and local representatives on issues including water resources, agriculture, ecosystem impacts, energy and coastal environments. NIDIS is working to provide dynamic and easily accessible drought information for the Nation by serving as an integrated knowledge center by identifying, collecting, and disseminating existing innovations at the national, regional, watershed, State, county, and private sector levels. NIDIS provides data to help decision-makers assess the risk of having too little water and

to prepare for and mitigate the effects of drought (such as farmers making decisions about crops, forestry professionals planning ahead for the next fire season, and urban water managers preparing for high-demand seasons). Still in its initial phases, NIDIS is continually developing more robust services and regional decision support resources.

While significant in their own right, these examples are only a snapshot of how, through a National Climate Service, NOAA can apply its current climate capabilities and mandates, and leverage the expertise and strengths of the other leading climate research agencies to address the growing demand for climate services. As NOAA works to define its role in a National Climate Service, we will continue to develop and expand, in partnership with the other leading climate research agencies, the products and services to assist a number of key social, economic, and environmental climate change decisions, particularly those at regional and national levels.

Examples of emerging issues that a National Climate Service could address through collaborative and coordinated effort among federal agencies and other partners include:

Mainstreaming climate change adaptation for critical infrastructure—Current infrastructure design criteria and construction codes may be inadequate for climate change and exacerbate vulnerability to increasing storm intensity and flooding. For example, along the U.S. Gulf Coast, from Houston, Texas to Mobile, Alabama, 27 percent of major roads, nine percent of rail lines, and 72 percent of ports in the area are built on land at or below four feet in elevation; a level within range of projections for relative sea-level rise in this region in this century. A National Climate Service would provide information that would allow the U.S. to relocate and/or secure these installments as well as improve planning for future infrastructure investments.

Delivering regional and decadal climate information—Currently, U.S. climate modeling efforts allow us to provide information at centennial and continental scales. With funds from the *American Reinvestment and Recovery Act of 2009,* NOAA will be able to continue to increase its computing power so that its climate models can provide information at the decadal and regional scales, which are most relevant to decision-makers. It is important to recognize that the reliability of this information depends on more than just greater model resolution. Critical research efforts will be required to ensure that all essential processes at these new scales are represented in the models in order to produce reliable information. This new information coupled with advances in tools and expertise led by the other leading climate research agencies will open the door to opportunities for a National Climate Service to develop and work with its partners to deliver authoritative products and services to users at scales previously not possible.

National security—Climate change has the potential to affect national security by reducing predictability and stability throughout the world, for example, through disruptions resulting from food and water shortage. The U.S. will also need to anticipate and plan for growing immigration pressures both at home and in other countries. A National Climate Service could help to prepare for and adapt to these changes by providing the observations and forecasts that can be utilized by agencies such as U.S. Agency for International Development and the Department of State to develop policies and action to mitigate these impacts (e.g., new agricultural practices).

Underpinning research—Providing reliable climate information at the fine spatial scales relevant to human activities requires further and rapid progress in scientific understanding and quantitative predictions. NOAA, in partnership with other agencies, will enhance essential climate research programs to shape and inform our fundamental understanding of climate change, its pace, and its consequences. Meeting these new challenges and delivering timely, relevant, and the best scientifically-informed climate information and services to decision-makers will require a coordinated effort that builds upon and expands the Nation's observational, research and modeling infrastructure.

CONCLUDING REMARKS

This is a time of rapid change. The pace and nature of changes in the Earth's climate reinforce the need for delivering targeted climate services at appropriate scales. We will need to draw from the expertise of all federal agencies to support the development of science-based and user-driven climate services to enable decision-making. Development of a National Climate Service will take leadership, sustained efforts, and a commitment across the Federal Government to work collaboratively.

Much work lies ahead of us. NOAA will contribute to this effort by building on its existing capabilities, partnerships and networks to deliver an evolving suite of climate information and services, in collaboration with our partners. We are prepared to provide leadership, in partnership with other federal agencies, to the design and development of a National Climate Service through an interactive dialogue that engages the breadth of climate service interests, including service providers, researchers, and users.

I look forward to working with the Office of Science and Technology Policy, other federal agencies, our partners, and this committee to further evaluate the merits of this effort.

Thank you very much for the opportunity to testify today. I look forward to answering your questions.

BIOGRAPHY FOR JANE LUBCHENCO

Dr. Jane Lubchenco, a marine ecologist and environmental scientist, is the ninth Administrator of NOAA. Her scientific expertise includes oceans, climate change, and interactions between the environment and human well-being. Raised in Denver, she received a B.A. degree in biology from Colorado College, a M.S. in zoology from the University of Washington and a Ph.D. in ecology from Harvard University. While teaching at Harvard (1975–1977) and Oregon State University (1977–2009), she was actively engaged in discovery, synthesis, communication, and application of scientific knowledge.

Dr. Lubchenco has studied marine ecosystems around the world and championed the importance of science and its relevance to policy-making and human well-being. A former President of the American Association for the Advancement of Science (AAAS), the International Council for Science and the Ecological Society of America, she served 10 years on the National Science Board (Board of Directors for the National Science Foundation). From 1999–2009 she led PISCO, a large four-university, interdisciplinary team of scientists investigating the large marine ecosystem along the coasts of Washington, Oregon and California. She has a special interest in Arctic ecosystems, with recent work in Svalbard, Greenland and the Alaskan arctic.

Dr. Lubchenco has provided scientific input to multiple U.S. Administrations and Congress on climate, fisheries, marine ecosystems, and bio-diversity. Dr. Lubchenco served on the first National Academy of Sciences study on 'Policy Implications of Global Warming,' providing advice to the George H.W. Bush Administration and Congress. In 1997 she briefed President Clinton and Vice President Gore and Members of Congress on climate change.

Her scientific contributions are widely recognized. Eight of her publications are "Science Citation Classics"; she is one of the 'most highly cited' ecologists in the world. Dr. Lubchenco is an elected member of the National Academy of Sciences, the American Academy of Arts and Sciences, the American Philosophical Society, and the Royal Society. She has received numerous awards including a MacArthur ('genius') Fellowship, nine honorary degrees, the 2002 Heinz Award in the Environment, the 2005 AAAS Award for Public Understanding of Science and Technology and the 2008 Zayed International Prize for the Environment.

Dr. Lubchenco co-founded three organizations that communicate scientific knowledge to the public, policy-makers, the media and industry: (1) The Leopold Leadership Program (teaches environmental scientists to be effective communicators), (2) COMPASS (the Communication Partnership for Science and the Sea, communicates marine sciences); and (3) Climate Central (a non-advocacy source of understandable scientific information about climate science and solutions). She co-chaired the Synthesis for Business and Industry of the Millennium Ecosystem Assessment, an international scientific evaluation of the consequences of environmental changes to human well-being. She also served on the Pew Oceans Commission and the Joint Oceans Commission Initiative and the Aspen Institute Arctic Commission.

DISCUSSION

Chair BAIRD. Thank you very much, Doctor. I will recognize myself for five minutes.

THE STRUCTURE OF A NATIONAL CLIMATE SERVICE

You know, when you talk about the implications of this, Mr. Inglis talked about fires. We look in our area, in terms of El Niño

events, whether they or not will happen has profound implications for our agricultural industry, our power supply, a host of other, fishing, for example, in the Northwest, as you know better than I. So, this is really something we recognize, on this committee, the importance of.

The question, then, is really what are the best ways, how do we best go about structuring this? Given that there are various aspects, as you mentioned, various aspects of what the data can be used for—we will hear from a panel in a minute about that—but also, various entities within government that also provide some of the pieces.

What are your thoughts about the best way to put the pieces together? Do we have a coordinating body? Do we create a new entity? Do we draw upon the various agencies separately, or do we integrate them?

What are your thoughts? And we will hear, there may be other thoughts later on here, but what are your ideas about this?

Dr. LUBCHENCO. Mr. Chairman, I believe that this topic has actually been addressed by some of the different studies that have looked at this concept of National Climate Service, and there are some continuing themes that loop through each of those different reports: the need for an integrated national effort, number one; an effort that draws on the wealth of existing research information, and is tied to the ongoing discovery of new information; three, an effort that is connected to and cognizant of users' needs; and three, that draws—four, that draws on the wealth of experiences that currently exist through existing federal agencies, for example, within NOAA, the experiences we have had with the National Weather Service, but the Regional Climate Centers, the Regional Integrated Assessment and Service Organizations that are providing a wealth of existing climate services.

So, I think, to sum that up, there are a lot of existing pieces in play. I believe that a single effort is needed to look broadly across those capacities and lessons learned, and to integrate them at the federal level. I would envision an interagency process led by the Office of Science and Technology Policy as the appropriate entity to really take stock of, and lead that designing effort. We now, I think we have gotten to the point where we are in agreement that something is needed, something that does not now exist, and the question is how to design that.

Typically, in an interagency process, there is a lead federal agency. NOAA is willing to play that lead. We would not insist on that. It just seems logical, because of the wealth of our capacities, capabilities, and experiences. But I believe this really is an interagency process, but one that does not ignore the regions and the local experiences and capacities, because it really is delivery of services at the local and regional level that should be the focus.

Chair BAIRD. I share that belief that NOAA is the best suited and qualified, and has the longest history of dealing with this, so I would certainly support that.

APPLICATIONS OF A NATIONAL CLIMATE SERVICE

Let us talk a little bit about the applications now. How would you envision, obviously, for agriculture, this is critically important,

when you look at, and downstream, for those of us who eat the products of agriculture, it is important. When we look at predictions of what might happen, for example, to the regional ability to grow different crops, or needs for irrigation or chemicals, or other factors, how do you envision getting the information out effectively to the various regions of the country, which will have different needs, based on crops and climate in those regions?

Dr. LUBCHENCO. Mr. Chairman, our current ability to make reasonable forecasts about climate scale information is really best at the scale of the entire continent, and best at the scale of a century. Neither of those time or space scales is what we need. Our modeling capacity is getting better and better, and with the recent new supercomputers, we have reason to believe we will be able to deliver regional scale information, hopefully on the 20, 30, 50 year timeframe.

So, our capacity to provide the kind of information that users are asking for and needing is getting better and better, which is why it is so timely to be designing the mechanism for sharing that information with users that are asking for it.

So, relative to what trees to plant, what crops to plant, how to think about water management, how to think about fire management, how to think about building coastal cities, all of those will require information that is at that 20 plus time horizon, and more at a regional scale. So, that is where we need to be heading.

Chair BAIRD. So, we have a combination of a challenge of the research necessary to refine that precision of our predictions, but also, then, a process of making that, those predictions relevant and valuable to the consumers in the field.

Dr. LUBCHENCO. Yes, Mr. Chairman, although I think it is probably more appropriate to be talking about forecasts as opposed to predictions. Predictions implies more certainty than will probably be appropriate, but forecasts, much like we do for the weather forecast, with some uncertainty described, is probably what we are looking at.

Chair BAIRD. Thank you. I recognize Mr. Inglis for five minutes.

Mr. INGLIS. Thank you, Mr. Chairman. Dr. Lubchenco, we very much appreciate your work at NOAA.

THE SIZE OF FEDERAL GOVERNMENT

And you know, I was interested in your observation that NOAA is well positioned to collaborate, and I can definitely speak to that, having been with Dr. Baird in Australia, and seeing employees of NOAA there. It is very impressive that NOAA is that extramural, I think you call it, that we are, I am also on Foreign Affairs as well as the Science Committee, and realizing the opportunity there to generate and keep, in the case of Australia, good will, by having our employees present there working on something that is very important to them, the Great Barrier Reef, which also is important to us in gathering science and information. This really is, it substantiates what you were saying about NOAA being well positioned to lead this collaboration.

So, tell me, for folks that are concerned about creating new things in the Federal Government, the goal, it seems to me, is to create stronger, smarter, simpler, more flexible kinds of govern-

ment agencies. How would this fit with that criteria, or would it just be growing larger? The concern that a lot of people have is we grow the Federal Government larger.

Dr. LUBCHENCO. Thank you for that question. I think that it is likely the case that we can make better use of many of our current capacities, make them more efficient, make them more synergistic, connect, set international, federal, regional, and local efforts in a more efficient fashion.

That said, what will be required, and what is already being asked by many users of us, will require significantly greater investment than currently now exists, so I think we can do some combination of synergies and finding efficiencies, but that alone will not be able to deliver the range of products and services that we believe would best serve the Nation.

Mr. INGLIS. So, in other words, your hope is, I suppose to actually get more bang for the buck, in terms of the expenditures, more synergistic effects. Of course, that is what we are looking for in the Federal Government, it seems to me, as we think about ways to make it stronger, simpler, more effective, more efficient.

And so, I hope that that is what we can achieve here.

Dr. LUBCHENCO. Congressman Inglis, could I clarify. I do think that that is possible, but I also think that we are talking about something new, as well, that there are new, there will be new efforts required to, in addition to the synergies and the efficiencies, to be delivering the services that we think are going to be needed.

Mr. INGLIS. Right, and of course, our challenge, as Members of Congress, as we encounter these new challenges, we need to go figure out what it is that we have already licked, and get rid of some of those things. You know, there are places in the Federal Government where agencies keep on going forever, long after the problem is licked.

So, hopefully, we can do that together. We can add to capabilities here, but eliminate things elsewhere. Perhaps in NOAA, but certainly, across the Federal Government in other places.

So, I have just a brief little time left, but it is a good way to ask the question, I suppose, with a time limit. Let us say you got on the elevator out here, and somebody told you just nonsense, that there are anthropogenic causes of climate change. What is your elevator answer? You have got three floors, you have 49 seconds to get down to the bottom. What would you say? I am just curious.

Dr. LUBCHENCO. Regardless of what you think the causes of climate change are, I think the evidence is unassailable that there is change underway, and most people are experiencing that in their daily lives. The temperatures are increasing. We are seeing more extreme precipitation events, more floods, more droughts. We are seeing, as a consequence, more fires, more insect outbreaks. Sea level is rising, and the oceans are becoming more acidic, and all of those changes are well documented.

Now, the challenge, relative to the topic of today's hearing, is how do we deal with those changes in a way that is most useful?

Mr. INGLIS. Great. Thank you. The elevator just got to the first floor.

Chair BAIRD. Thank you, Mr. Inglis. I recognize Ms. Woolsey for five minutes.

Ms. WOOLSEY. Thank you very much. Thank you, Doctor, for being here. We are so pleased to have a real scientist leading your organization, so congratulations.

Dr. LUBCHENCO. Thank you, Congresswoman.

Ms. WOOLSEY. It gives all of a lot of confidence that——

Dr. LUBCHENCO. Thank you.

MONITORING GREENHOUSE GASES

Ms. WOOLSEY.—we are going to go in the right direction. In your testimony, you talk about global climate change and how a National Climate Service can be used in mitigation and adaptation, and to the problem that we are creating.

So, this leads me right up to where do you see, or where do you see the role of the National Climate Service in monitoring greenhouse gases?

Dr. LUBCHENCO. Congresswoman, it really is important that as we think about different types of mitigation, and as we work toward the best way to reduce greenhouse gas emissions, we will need to monitor the types of, or the amounts of greenhouse gases that are being emitted, and that are in the atmosphere, and we currently do some of that. We need to be doing more of that, and we need to have mechanisms to be reporting that on an ongoing basis.

So, I think there is absolutely a need to have that capacity, and——

Ms. WOOLSEY. So, would that be, when you talk about, Congressman Inglis asked about, you know, growing our government, that new doesn't mean that we replace existing, so would this be some of the new responsibility?

Dr. LUBCHENCO. We already do some monitoring of greenhouse gas emissions. We need to be doing that on an ongoing basis, and probably at greater scale, for verification purposes. So, that need will continue and will grow, along with the need to provide information that will focus more on the adaptation end of the climate challenges.

POTENTIAL NEW PROGRAMS

Ms. WOOLSEY. So, are there any other examples you would like to give us of what new programs we will need, while we continue with our existing important NOAA programs?

Dr. LUBCHENCO. Well, I think some of the other benefits of having something like a climate service, would be enabling those in the private sector who are thinking about new types of renewable energy sources, information that would enable them to do a better job of having successful businesses. Say, for example, that you are interested in building a wind farm. You would like to know not where the winds have been good for the last hundred years, but where they are likely to be good for the next hundred years, and so, that information would be extremely useful to you in helping to design where to place, where to site, you know, decide whether this is a good investment or not.

So, there are many kinds of services that a climate, National Climate Service could provide that would help with creation of new jobs, new industries, and provision of clean energy.

Ms. WOOLSEY. So, do you see a need for the oceans being considered in relationship to climate? Where is that going to come into play?

Dr. LUBCHENCO. Oceans in coastal areas are being strongly affected by the increased greenhouse gases in the atmosphere. This committee has been, and the Chairman in particular, have been strong champions of focusing on the changing chemistry of the oceans. As oceans are absorbing the carbon dioxide, they become more acidic, and that, in turn, is affecting our ecosystems, especially along the West Coast, but also elsewhere.

In addition to that, ocean ecosystems are responding, as a result of changes in temperature, changes in ocean currents, changes in coastal winds, and then, of course, sea level rise. And all of those consequences of climate change to ocean ecosystems are affecting the way people interact with those ocean ecosystems, whether they are on the land side or the ocean side. And as we deal with this range of changes that is underway, information to help guide decisions about growth in coastal areas, planning of where to move infrastructure, planning of where to move communities, where to build airports, where to build wind farms, wave energy facilities, all of those will be vastly enhanced by having more, by having information that we envision being able to be provided by a National Climate Service.

Ms. WOOLSEY. Thank you very much, Mr. Chairman.

Chair BAIRD. Thank you, Ms. Woolsey. Dr. Ehlers.

Mr. EHLERS. Thank you, Mr. Chairman.

I have no questions, but I did just want to say I am very pleased that Dr. Lubchenco has received this appointment, and I look forward to a lot of good work happening in NOAA in the future. Thank you.

Dr. LUBCHENCO. Thank you, Congressman, and thank you for all of your efforts over the years as a strong champion of science.

Mr. EHLERS. Thank you.

Chair BAIRD. There has been no stronger champion over the years than Dr. Ehlers, and you will appreciate his expertise in many realms, and Dr. Ehlers, thank you.

Mr. Rohrabacher.

OBSERVING CLIMATE CHANGE

Mr. ROHRABACHER. Thank you very much, Mr. Chairman, and I have been a long-time fan of NOAA, and I wish you success, and look forward to working with you.

Chair BAIRD. Dr. Lubchenco, be advised that Mr. Rohrabacher is an avid surfer, and so he brings us the perspective——

Dr. LUBCHENCO. Excellent.

Chair BAIRD.—of someone who spends a lot of time in the water.

Mr. ROHRABACHER. As well as scuba diver, let me note that, but not as avid a scuba diver as my Chairman.

The climate change, you are referring to climate change—were you, at any point in your career, someone who used the words global warming instead of climate change?

Dr. LUBCHENCO. Yes, Congressman, I think most of us have used both of those terms.

Mr. ROHRABACHER. Why is it that you stopped using the word global warming and have now moved to climate change?

Dr. LUBCHENCO. The words global warming, to me, imply something that is gradual, and something that is only about temperature, and the sum total of the changes that are underway are much more than gradual and just temperature.

Mr. ROHRABACHER. But the temperature change itself, correct me if I am wrong, for the last eight years, there has not been higher temperatures. Could that have something to do with your change of wording, from global warming to climate change?

Dr. LUBCHENCO. No, sir. I don't believe that the change of wording, at least in the way that I understand the words, is anything other than an honest attempt to communicate better with the public about the range of changes that are underway.

Mr. ROHRABACHER. Well, I am sure you are always, I am in no way implying you ever were, or people who I disagree with have ever been dishonest with the public. Let me just put that on the record. People can have honest disagreements, but also, people can be wrong, and my suggestion is that there are so many people who are using the word global warming, and now, don't use it, because it hasn't been getting warmer. I think it is, and I am not saying this about you, but for many other people, I think it is that they were wrong and refused to admit it.

Let me ask you, so is that correct that there has not been warming on the planet, generally, in the last eight years?

Dr. LUBCHENCO. Congressman, I think, if, may I use an analogy that is on the beach, if you will? If you are standing on a shore that you have never been at before, and you are trying to decide if the tide is going in or coming out, and you watch eight waves come in, you can't tell whether the tide is ebbing or flowing. You need to look at it over a longer period of time.

The same is true with climate records. Looking at an eight-year record is insufficient to tell you if there is any meaningful change through time. You need a longer period of time to be examining whether there really is a change, whether it is going one way or another.

Mr. ROHRABACHER. I was assuming that the Weather Service and the scientists that were using the words global warming, had actually been studying the trends over long periods of time. Tell me, is the climate of this planet, someone who is an expert in this area, would you say the climate on the planet over the millions of years of our planet's history has been a stable climate, or someone that has been volatile?

Dr. LUBCHENCO. Over millions of years, the climate has gone through many different cycles. We have good evidence, going back some 650,000 years, from ice core data, for example, that give us better insight into that fairly long period of time.

And during that interval, we know that what is happening now is outside of the normal ranges of the climate cycle.

Mr. ROHRABACHER. But there have been major changes in the climate over that time period. About ice cores, does the ice core prove, and I have several scientists that we have put in the record here,

major heads of major university science laboratories, et cetera, that have said that the idea that CO_2 introduction has caused the climate to change was wrong, the wrong analysis ten years ago. And they have studied it, and they now believe that it is warming that causes the CO_2 to go up, and not the other way around.

Do you disagree with those scientists?

Dr. LUBCHENCO. I disagree with that, and I think there has been resolution of that particular issue. I think it is now commonly accepted that increases in carbon dioxide are, in fact, causing both a general warming trend and increasing variability of the climate, and there is good evidence that that is happening.

Mr. ROHRABACHER. And has the CO_2 gone up in the last eight years, and we have not seen—instead, we have a cooling now, yet the CO_2 continues to go up?

Dr. LUBCHENCO. Congressman, this is the same phenomenon that I was describing earlier. Eight years is not enough to detect a trend in a system that has some natural fluctuation, and we are seeing over the last century, significant warming through that time, and very significant increases in carbon dioxide. I think there is considerable unanimity within the scientific community on those points.

Mr. ROHRABACHER. I would suggest, and I have already put it in the record, many scientists, prominent scientists who don't agree with that. And my time is up. Thank you very much, Mr. Chairman, and thank you to the witness.

OCEAN ACIDIFICATION

Chair BAIRD. Thank the Chairman, or Mr. Rohrabacher. I don't plan to have a whole second round, but what are we seeing in the area of ocean acidification, over the time period? This is basic chemistry. Is there anyone who would suggest that more CO_2 is in the air is going to lead to less acidification of the ocean and less adverse effects? You are an expert in that particular area. Could you enlighten us a little bit about that?

Dr. LUBCHENCO. Mr. Chairman, this is an area where there really is no controversy at all. It is very straightforward chemistry. As you increase the amount of carbon dioxide in the atmosphere, the ocean absorbs it, and that makes ocean water more acidic is the very simple, straightforward thing.

We know that over the last 100 years or so, the amount of acidity in the ocean has increased by about 30 percent, and that is having a very significant impact on everything from coral reefs to the microscopic plants in the ocean, the phytoplankton, on anything that has a shell or a skeleton, from mussels to clams to sea stars, sea urchins, oysters. And all of those changes that are underway are likely to continue for some time, because of the carbon dioxide that is in the atmosphere now.

Chair BAIRD. Even if we were to stop additional CO_2, we would still have continued acidification impacts?

Dr. LUBCHENCO. We would indeed.

Chair BAIRD. Unless any of my colleagues have urgent questions, I think we will thank the Director for her service, look forward to many future conversations, and working closely with you and your

agency on developing a National Climate Service and legislation to support that.

And with that, we will take a brief break. Dr. Lubchenco, you are excused, and thank you very much for joining us again. Hope to see you soon.

Dr. LUBCHENCO. Thank you so much.

Chair BAIRD. A very brief break, as we seat the next panel, and our staff puts the proper nametags in the proper place. Thank you again, Dr. Lubchenco, and thank my colleagues.

Panel II

Our panel is now seated. We want to thank the panelists. I also acknowledge we have been joined by Eddie Bernice Johnson, as well, the gentlelady from Texas, and we will now introduce our second panel. I thank you for your patience, gentlemen, and thank you for your background and contributions today.

Dr. Arthur DeGaetano is the Director of the Northeast Regional Climate Center. Dr. Eric Barron is the Director of the National Center for Atmospheric Research. Dr. Philip Mote is the Director of the Oregon Climate Change Research Institute and Oregon Climate Services at Oregon State University. And Mr. Richard Hirn is the General Counsel and Legislative Director for the National Weather Service Employees Organization.

Thank you all for being here very much. We look forward to your comments. As mentioned earlier, each witness will have about five minutes to speak, and you will watch the lights, and they will turn yellow when you are about one minute, and we try to keep it as close as we can to five, and then, we will follow with a series of questions by panel.

And with that, we begin by recognizing Dr. DeGaetano. Thank you.

STATEMENT OF DR. ARTHUR DEGAETANO, DIRECTOR, NORTHEAST REGIONAL CLIMATE CENTER, CORNELL UNIVERSITY

Dr. DEGAETANO. Thank you, Chairman Baird.

I am a professor at Cornell University and Director of the Northeast Regional Climate Center. The NRCC is one of six Regional Climate Centers that have been supported by Congress for nearly two decades. It is administered by NOAA.

We provide timely, efficient, and reliable climate services to a wide variety of sensitive sectors within our regions. I hope this experience will serve as a model for climate services in the years to come. In the next few minutes, I will elucidate several key characteristics of climate services, based on the 25 year history of the RCC program.

As I expand on these characteristics, please try to see the ties between them, because just like effective climate services cannot be done by any one organization, the characteristics of climate services in general are also interwoven.

The first characteristic is partnership and integration. Partnerships are critical. The Climate Centers have seen this in our interactions with the National Climatic Data Center, and with partners represented by many of my fellow witnesses. Web-based tools de-

veloped by the RCCs facilitate climate services by local National Weather Service offices, State climatologists, and Natural Resource Conservation Service offices in every U.S. county. They integrate data from across the State, local, and other federal networks that are used by these partners, another key area of integration.

Partnerships should also extend to our stakeholders. Trust-based, active, two way dialogs between climate scientists and users of climate information is critical for effective climate services. Examples based on these feature can be relatively simple, but solve a substantial problem for the user. Like the investment banking industry's need for degree days to be tabulated from Friday to Thursday to match industry practices. Or more complex, such as ongoing applied research to develop climate-dependent tools for monitoring and controlling the spread of vectors of West Nile virus.

Such data-driven climate decision models will become more and more entrenched in climate services in the coming years. It is not enough to just provide climate data. Users require climate products, and these analyses must be capable of interacting with other models. A robust computer infrastructure, that operationalizes research results and dynamically links data to decision tools, is a third climate service component. We have seen this in our interactions with the RISAs. The RCC computer infrastructure interfaces with hydrological models developed by the Climate Impact Groups at the University of Washington, in Chairman Baird's home state, providing real-time data for water management decisions.

Responsiveness to local and regional issues is a fourth component. Responsiveness not only includes being there day in and day out to provide the types of operational products described previously, but it also includes the ability to react when unanticipated climate anomalies develop, be they hurricanes, droughts, or other crises indirectly related to climate. Just the other day, my Center provided data to help track the spread of the hemlock woolly adelgid, an invasive pest.

Responsiveness also includes being in tune with important political, social, and environmental considerations within a region. A Climate Center example from the Northeast involves the influence of climate on nitrogen runoff into the upper Susquehanna and Chesapeake Bay. The above example also highlights interdisciplinarity. Having climate service partners affiliated with universities offers ties to disciplines outside the atmospheric sciences, provides a link between basic and applied research, and capitalizes on established affiliations with cooperative extension, the Land Grant college system and NOAA Sea grant.

I once heard a farmer say that he deals with change every day, changes in technology, changes in economics, changes in environmental regulations. Climate is only one of the many changes facing agriculture and other industries. This highlights the final element of a National Climate Service, that if you are prepared to deal with adaptation to climate change.

I leave this critical component for last, to make the point that traditional approaches to solve past climate problems, like I have discussed, trust-based relationships with stakeholders, partnership, interactive decision tools, modeled link with data, collaborations be-

tween climate service providers and researchers from other disciplines, provide the foundation for responding to concerns about future climate variations and change.

Let me conclude by saying that the United States needs a comprehensive National Climate Service that has the ability to address the broad spectrum of climate needs facing the Nation. The existing core set of organizations and capabilities provides a useful and functional framework. To meet newer challenges, this incomplete infrastructure requires consistent and reliable support, augmentation of capabilities, and much better integration across a wide variety of boundaries.

NOAA capabilities and affiliated programs, such as the Regional Climate Centers, will be integral and necessary components, but alone are not sufficient.

Thank you for your attention.

[The prepared statement of Dr. DeGaetano follows:]

PREPARED STATEMENT OF ARTHUR DEGAETANO

Mr. Chairman and distinguished Members: Thank you for inviting me to testify before this subcommittee, to address the expansion of climate services within the National Oceanic and Atmospheric Administration (NOAA). I am a Professor in the Department of Earth and Atmospheric Sciences at Cornell University and Director of the Northeast Regional Climate Center (NRCC). The NRCC is one of six Regional Climate Centers (RCCs) that have been supported by Congress for nearly 25 years. Over this time the RCC Program, administered by NOAA, has provided basic climate services in a timely, efficient and reliable manner to a variety of climate sensitive sectors within their regions. I hope this experience will serve as a model for expanded climate services in the years to come, particularly with regard to the vital requirement that climate services be regional in nature and responsive to stakeholder needs, and transition to a comprehensive Service that can meet sector needs to respond to future uncertainty in a changing climate.

The six RCCs serve all fifty states in the Nation. Through its history, the RCC Program has coordinated with partners in the NOAA National Climatic Data Center (NCDC), the NOAA National Weather Service (NWS), the American Association of State Climatologists (AASC), NOAA Cooperative Institutes and research programs, numerous State and federal agencies, private industries, and individual citizens to deliver a comprehensive suite of climate services at national, regional, State and local levels. This successful effort provides jointly developed products, services, and capabilities that enhance the delivery and usefulness of climate information to the American public. As NOAA and Congress work to help society adapt to climate change and variability, these collaborative efforts form a framework for data stewardship, climate services, climate assessment, and applied research geared toward helping individuals, communities, government agencies, and industries make informed decisions using climate information.

Strong Congressional support for the RCC program over the last two decades has allowed for development of trust-based relationships between the Centers and decision-makers from various economic sectors. These relationships have been fruitful for both the users as well as the RCCs. Decision-makers receive the data and information they need in a format, time-frame, and manner that is most useful for their application, while the RCCs capitalize on the feedback received from users of climate information to develop robust and efficient data delivery systems, drive applied research projects, and synthesize the climate-related applications that impact social and economic sectors within their regions.

Dependable relationships with credible partners, accumulated climate knowledge and a robust computing infrastructure are critical components for effective climate services at local to national scales. Attempting to recreate this efficient, established, proven, and reliable system, would be wasteful in terms of resources and disruptive to a large user base that relies upon operational RCC data products 24 hours a day. Through this testimony, I hope to elucidate several key characteristics of climate services based on the accumulated experience of the RCC program. Examples are used to illustrate existing features that could be incorporated into an expanded National Climate Service. Drawing upon their history and familiarity with user communities, the RCC's vision for a National Climate Service includes:

- Providing services based on direct interaction with climate stakeholders
- Enhancing established climate service partnerships
- Distributing accurate and unbiased climate data, data-products, and summary information in response to changing user needs
- Developing decision support tools through interdisciplinary applied research
- Educating stakeholders on emerging regional climate issues
- Developing adaptation strategies for changing environmental, technological and societal conditions

Key Components of a National Climate Service

Integration—Local to National

In partnership with NOAA and the American Association of State Climatologists (AASC), the RCCs envision an integrated climate service structure that supports improved decisions to enhance industries, protect the environment, and promote public safety at State, regional and national levels. Through integration, national climate services will benefit from

- Access to local data sources from regional, State, local and private networks
- Dynamic products that span time scales from historical to real-time to near-term forecast to longer range climate projection
- Local knowledge of climate impacts, climate extremes and emerging issues
- Synchronized data values and consistent analyses

Such a structure is already in place within the RCC regions.

- The Western RCC (WRCC) has teamed with the State of California to integrate NOAA data with observations from a variety of State, local and other federal networks. This expanded data network, when linked to WRCC analysis software and interpretive human expertise, informs decisions related to water resources, fire risk and air quality.
- At all RCCs, a distributed climate data access system (ACIS) enables State climate offices to respond to requests for climate information from engineers, insurance companies, banking institutions and energy firms using the most up-to-date NOAA data and standardized processing routines.
- Crop disease risk models developed by the Northeast RCC merge hourly NOAA data, observations from privately operated weather stations and NWS gridded forecasts. NRCC data systems provide a mechanism for NWS access to the private climate observations.

Active Local Stakeholder Engagement

Through decades of experience, the RCCs have learned that effective and meaningful climate services must be defined broadly to satisfy stakeholder needs. Climate services should satisfy the domain-specific needs of stakeholders in ways that can be directly assimilated into their business practices and decision strategies. Effective climate services should include:

- Two-way dialogues between climate scientists and users of climate information
- Timely access to quality climate data, products, and analyses from integrated data sources that incorporate State, regional, and national data networks
- General and specific assessments of climate conditions at pertinent spatial and temporal scales
- Responsiveness to new climate issues as they arise, such as adaptation to climate change and variability
- Access to research results pertaining to basic and applied climate issues
- Decision support tools developed for domain-specific applications

An example from the Northeastern United States epitomizes this strategy. Heating degree days have been used as a common measure of heating demand, and hence fuel usage, for decades. These data, available from NOAA and a variety of other sources, have typically been tabulated on a weekly basis from Sunday through Saturday. Through discussions with UBS, a nationwide investment firm, the NRCC learned that this definition of a week did not coincide with energy trading practices which operated on a Friday-Thursday time interval. The mismatch in summary period affected the accuracy of the forecast models used by the industry. By working with these companies and the NOAA Climate Prediction Center, the NRCC now provides these data to USB and other investment firms in a format that addresses their needs.

Adaptation Strategies for Climate and Environmental Change

A core component of a National Climate Service should include the capacity and ability to provide data and insight on climate change adaptation strategies. The RCCs have been increasingly called upon for information related to future climate conditions. Users are more aware of variations in climate conditions and require information to assist them in managing year-to-year climate variations and adapting to changing climate conditions. As with traditional approaches to solve past problems, those that focus on climate change adaptation require extensive stakeholder dialogue. Furthermore, the inherent uncertainly of longer-term climate projections makes established trust between climate service providers and decision-makers an even more important component of climate adaptation research, outreach and service. Again from past experience, it is evident that these types of relationships can best be established at local, State and regional levels. To address climate change adaptation a national climate service should:

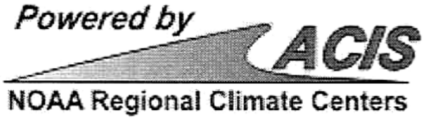
- Assess vulnerability to climate change impacts and research appropriate strategies and plans to reduce such vulnerability at local, State, regional, and national levels
- Develop dynamic climate information products, databases, decision tools, and services for decision-makers and policy-makers at multiple temporal and spatial scales

- Educate stakeholders about the potential uncertainties in climate projections and work with decision-makers to determine how best to apply these projections in light of uncertainty

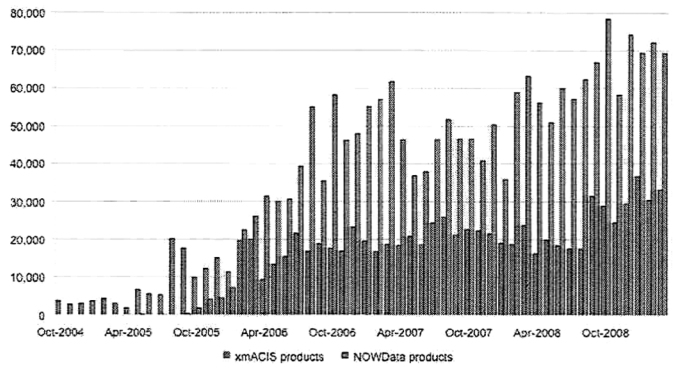
Users are more comfortable when tools for climate adaptation are derived from existing climate products and decision support systems available through established relationships. Most of the data, tools and products currently provided by the RCCs can be used or modified to support climate change adaptation. The climate services partners such as the RCCs and AASC have the expertise to help local sectors identify vulnerabilities in relation to climate. The key to using these tools effectively will be to understand how climate is changing—what might change, what will be the magnitude, and over what time periods. For example, a crop yield model used currently to project seasonal yields can be used to plan for adaptation to climate change by providing outcomes for different scenarios of temperature, precipitation, and other climate-related inputs in the model. New risk-management tools can be developed to help utilize these results for making decisions about adaptation. Because of the RCC understanding of many stakeholder needs, the RCCs help agencies determine critical climate thresholds that will impact a particular sector.

Innovative Environmental Data Management

The RCCs have been in the forefront of developing operational climate data support systems. The Applied Climate Information System (ACIS) is the foundation for RCC data management and electronic information delivery. ACIS was developed to provide operational efficiency, redundant reliability, and flexibility to accommodate evolving information system configurations and needs. ACIS is becoming an effective operational component of international GEOSS activities through a partnership with the Northrop Grumman Corporation. The flexible design of ACIS provides data to web servers and services, automated data delivery systems, and on-demand data polling from remote users and user applications. The RCCs envision such a system as a key component of a National Climate Service. It already provides operational support to federal climate service providers and the general public through:



- **xmACIS**
  An interface for NOAA partners to access RCC data products and data holdings that alleviates the need to maintain and update separate databases at individual local NWS offices.
- **NOWData**
  An abbreviated version of xmACIS designed for use by the general public and available on each local NWS office website.
- **ThreadEx**
  A product developed in collaboration with the RCCs, NWS, NCDC, and The WeatherChannel to standardize the reporting of weather extremes.
- **AgACIS**
  Specially designed climate data products for use by Natural Resource Conservation Service field offices in each of the 3140 U.S. counties.
- **WxCoder III**
  A web-based interface that allows NOAA Cooperative weather observations to be entered electronically, providing timely access and eliminating the need to digitize handwritten observations.



These systems deliver tens of thousands of products every month and provide a cost-effective method to deliver NOAA and non-NOAA climate data and products to the public.

Information systems such as ACIS also provide a means for linking decision support tools developed through NOAA research programs such as the Regional Integrated Sciences and Assessments (RISA), Sector Applications Research Program (SARP) and Transition of Research Applications to Climate Services (TRACS) program to real-time operational climate databases. The RCCs expect that ACIS will be required to transition these research results into operational products. Such data systems will also be advantageous, as they have the ability to seamlessly incorporate data from disparate networks, remote-sensing platforms and meteorological and climatological models into existing decision tools.

Responsiveness to Local and Regional Issues

A national climate service must be closely attuned to regional issues and ready to provide nimble and appropriate responses as anomalous climate conditions develop or unanticipated situations arise. Under such circumstances, the value of a National Climate Service is more clearly apparent. Effectively addressing these issues requires:

- Local knowledge of important political, environmental and social considerations
- Established trust-based stakeholder relationships
- Pre-existing tools, data and information ready for rapid application
- A network to engage stakeholders at State and local levels, such as the one that exists through the 50 State climatologists, the USDA Cooperative Extension Service and NOAA Sea Grant

The regional diversity of local climate issues that need to be addressed by a National Climate Service is best illustrated by examples from each of the RCCs.

The Midwestern RCC

The Midwestern Regional Climate Center (MRCC) monitors the climate in the Nation's major corn and soybean growing region and provides tools for producer and agribusiness decisions. A method to produce county-level soil moisture measurements based on radar and precipitation measurements is used to produce up-to-date maps of soil moisture estimates in the Midwest. During the growing season, crop yield models provide yield estimates of corn and soybeans. Numerous agribusinesses, ranging from large international conglomerates such as Cargill, Inc. to seed companies and local producers, rely on RCC data and products to assess current conditions and provide guidance for operational decisions.

The Southeast RCC

The Southeast Regional Climate Center (SERCC) is taking the lead in exploring links between climate and health, largely because of the existing expertise of Center staff, the location of a major School of Public Health on the same campus, and the presence of the Centers for Disease Prevention and Control in the southeast region. At the federal level, RCC staff participates in an interagency working group assessing likely responses to public health threats posed by climate change. Major emerging roles for the Center are provision of information about climate variability and change at the local level in a form understandable to and usable by local, State and federal public health organizations, and assistance in translating the information into an assessment of potential health impacts.

The SERCC is also linking the health-related work with the disaster-related concerns of the Department of Homeland Security. SERCC, along with the Southern Regional Climate Center, is involved with assessing the direct physical threats posed by hurricanes to the Atlantic and Gulf coastlands. In addition, SERCC is in a position to assist in the development of strategies to deal with the health aftermaths of a hurricane strike.

The Southern RCC

Since 1992, the SRCC has provided decision support to the Louisiana Governor's Office of Homeland Security and Emergency Preparedness during tropical storm and hurricane events affecting Louisiana coastal communities. SRCC personnel provide observational data and interpretation of official NOAA forecasts and warnings that help emergency managers make informed decisions on evacuations, emergency sheltering, resource staging, rescue missions, and other critical decisions that depend on continually changing assessments of risk. In the past few years, LSU has increased its support of these activities providing additional services that include damage and mortality modeling, storm surge modeling, and post-storm recovery support in which the SRCC plays a major role.

The Northeast RCC

The NRCC frequently deals with urban issues related to water resources and temperature extremes. It has ties to corporations ranging from energy providers to investment banking firms. In addition, agriculture is an important industry in the region. Climate related decisions in this sector have both economic and environmental implications. Coastal issues are also within the realm of the center, given it is bordered by both the Atlantic Ocean and Great Lakes. A project that syntheses these interrelated issues deals with the management of agricultural nitrogen. Across department collaborations at Cornell have resulted in the creation of Adapt-N, a web-based tool that links high resolution climate data derived from Cooperative Network observations, radar estimates and meteorological model initialization fields with soil nitrogen and crop yield models. Adapt-N provides recommendations for nitrogen application rates in maize that incorporate ambient weather conditions. These recommendations optimize corn yield, while minimizing nitrogen losses. Nitrogen runoff within the Upper Susquehanna River Basin and ultimately Chesapeake Bay is a primary concern of the NY Department of Environmental Conservation and the Susquehanna River Basin Commission. Farmers using the tool also derive an economic benefit via more efficient nitrogen use.

The Western RCC

The WRCC addresses a broad spectrum of climate issues and user needs. For example, federal and State land management agencies rely on WRCC for data products supporting wildland fire decision-making, including data management of the 2,400 sites of the national Remote Automated Weather Station (RAWS) network, and archival of National Lightning Detection Network data for fire management use. WRCC has worked closely with the National Park Service nationwide on needs for and provision of weather and climate data and information for operations, research, and public interpretation of climate.

Drought has been present in the West every year since 1995 as a serious and persistent problem. WRCC has played an influential role in the development and implementation of the National Integrated Drought Information System and its western activities. The West has warmed much more than the rest of the U.S. over the past 35 years; this has significant implications for future water supplies, most of which rely on snowpack. Adaptation to climate variability and change are becoming a major WRCC theme. This Center specializes in mountain environments, the source of water, timber, recreation, minerals, renewable energy, and tourism, all greatly affected by climate. The region is over 50 percent public land, and WRCC interacts

with numerous federal, regional, tribal, State and county resource management agencies to monitor, understand, and provide sustainable utilization of these shared resources. Ecosystem services and environmental health are now seen as vital to the western economy, and are strongly tied to climate. WRCC provides front-line information delivery capability for NOAA, and in turn knowledgeably informs and participates in development of improved information capabilities tailored to the unique needs of this diverse region.

The High Plains RCC

The High Plains Aquifer (Ogallala) is one of the world's largest aquifers. About 27 percent of the Nation's irrigated land overlies this aquifer and about 30 percent of the U.S. ground water used for irrigation comes from the High Plains Aquifer. Clients using the HPRCC irrigation tools can select the nearest weather stations, the crop that will be addressed, its maturity level, emergence date, and enter local precipitation from the field of interest, if available. The output provides an estimate of how much additional water the soil can hold and a projection of soil water relative to crop water stress level. The goal is to keep the water in the soil well above the stress level and to leave enough room in the soil for any rainfall anticipated from the forecast. Informed scheduling of irrigations reduces the number of irrigations and thus conserves water, reduces energy used for pumping, minimizes runoff, and maintains potential yields (even in semi-arid climates).

The HPRCC is also engaged in climate variability and climate change analyses to build tools for current clients to provide assessments on possible climate change impacts on the Plains: future frost-free seasons, heat during the growing season, impacts on water use/yield and shifting of crop production zones.

Interdisciplinary Collaborations

Climate is just one of many issues that decision-makers must consider. Thus effective climate services must have the ability to synthesize non-climatic influences and data sources. Interactions between climatic and non-climatic factors are often nonlinear, particularly in situations where the climate and associated factors are changing. Economists, social scientists, communication specialists, innovative instruction experts, agronomists and entomologists represent interdisciplinary collaborations that the RCCs have fostered to address climate related problems. Scientists from these and other diverse fields are critical components of national climate services. An efficient means of integrating scientists is through the inclusion of research universities as partners in a National Climate Service. A National Climate Service-university relationship also benefits climate services in general by:

- Leveraging resources for research funds from federal, State, and private sponsors
- Fostering unique interdisciplinary collaborations
- Providing substantial cost sharing support
- Establishing links to Cooperative Extension and Sea Grant

The RCCs, AASC and RISAs currently provide ties to major U.S. universities. Each year the RCC base funding is leveraged considerably through external grants and contracts. The RCC directors are on faculty at major research universities and they maintain active research programs that further the goals of national climate services in data quality, novel data products and climate related decision-modeling.

Concluding Remarks

The United States needs a comprehensive National Climate Service that has the ability to address the broad spectrum of climate needs facing the Nation. These needs are spread across a wide diversity of disciplines and economic sectors that touch nearly every aspect of society. The existing core set of organizations and capabilities provides a useful and functional initial framework. To meet newer challenges, this patchy and incomplete infrastructure requires consistent and reliable support, augmentation of capabilities, and much better integration across a wide variety of boundaries. NOAA capacities and programs such as those we have outlined will be integral and necessary components but, alone are not sufficient. Climate is so pervasive an issue that the success of a National Climate Service, on the scale and broad scope that we need, can only derive from a sense of shared ownership of the Service among its widely scattered participants: federal, regional, State and local agencies and organizations inside and outside government. It is my opinion that this nation has the talent, the attitude, the motivation, and the resources to provide global leadership in this crucial endeavor.

In closing, I thank the Committee for inviting me to testify today.

BIOGRAPHY FOR ARTHUR DEGAETANO

Art DeGaetano is Professor in the Department of Earth and Atmospheric Sciences at Cornell. He is also the Director of the Northeast Regional Climate Center (NRCC) and Associate Chairman of Earth and Atmospheric (EAS). The NRCC's mission is to enhance the use and dissemination of climate information to a wide variety of sectors in the Northeastern United States in partnership with NOAA's National Climatic Data Center. Art serves as an associate editor for the *American Meteorological Society Journal of Applied Meteorology and Climatology*. Art has been at Cornell since 1991 serving as the Center's Research Climatologist until 2001. Prior to his arrival at Cornell Art was an Assistant Professor with the Meteorology Department at the South Dakota School of Mines and Technology in Rapid City. He received an interdisciplinary Ph.D. focusing on Climatology and Horticulture from Rutgers University in 1989.

Chair BAIRD. Thank you. Dr. Barron.

STATEMENT OF DR. ERIC J. BARRON, DIRECTOR, NATIONAL CENTER FOR ATMOSPHERIC RESEARCH; CHAIR, CLIMATE SERVICES COORDINATING COMMITTEE, CLIMATE WORKING GROUP, NOAA SCIENCE ADVISORY BOARD

Dr. BARRON. Chairman Baird, Ranking Member Inglis, and Members of the Subcommittee, thank you for inviting me to testify on the important topic of creating a National Climate Service. My name is Eric Barron, and I am the Director of the National Center for Atmospheric Research.

The climate debate has changed dramatically over the last decade. We now know that we are going to be forced to make a number of decisions that are climate-related, and some mix of adaptation and mitigation is going to be inevitable.

Unfortunately, our nation is not ready for those decisions. It lacks the capability to provide a diverse range of climate information that could benefit society. The simple fact of the matter is there is no single source of authoritative, credible, and useful information that will allow society to span the connections between climate and human health, water, energy, changes in severe weather, agriculture, and environmental stewardship.

It is interesting, every time I talk to a natural resource manager, I discover that many of them just don't know where to go to get the information that they need, and many of them are particularly concerned that they need information that is authoritative, the very best information available, if they are going to make decisions that can withstand the tests of our society or even of litigation within our society.

You know, consider the fact that we have dozens of climate models out there. Should a manager from Washington State or from South Carolina, California, Texas, or New York turn around and just pick whichever climate model they might want to use for a particular problem? Or would we rather have a single source, where you can go see the full range of predictions, and see with those full range of predictions, the information about uncertainties and their ranges, and other expert opinion?

In other cases, we know that if we can put users, information, and new research together, we can actually solve problems. We can tailor the information to the needs of a user, to remarkable benefit.

Recently, I chaired the Climate Services Coordinating Committee, a body within the Climate Working Group of NOAA's Science Advisory Board. The Committee prepared a report that was entitled *"Options for Developing a National Climate Service."* I would like to bring the conclusions of this report to your attention.

First, NOAA must play a key role in any climate service. This agency already contains many of the fundamental components of a climate service, and it has a considerable history of providing authoritative services to the Nation. However, in the panel's opinion, weather and climate within NOAA have to be better integrated, and research operations and users have to be better joined if their role is to be successful.

Second, in addition to NOAA, there are several federal agencies that are positioned to contribute expertise, information, and resources to support a National Climate Service. Each federal agency needs to define collaboratively its role and its level of commitment to this Service, and it can't be optional. It needs to be persistent and consistent.

Third, to make this work, the overall authority and guidance must be at the highest possible level within the federal system, preferably within the White House. There are simply too many pieces out there in too many federal agencies to have this work well without clear and potent leadership.

Fourth, a National Climate Service requires a defined, independent budget that is large enough to influence the direction of the Climate Service, and ensure that we achieve its mission. Some of our most successful regional climate services are chronically underfunded, and not all parts of this Nation are even represented. The Service needs a budget that is appropriate to match societal need.

Fifth, the Service needs to be able to connect with and actively engage a broad range of users. We need a nimble and flexible structure that empowers users, that can put industry at the table, that can promote interaction between users and the research community. Frankly, this is something that the Federal Government doesn't do well. Our view is that we need a separate consortium or nonprofit that is directly funded through a lead agency, and is designed specifically to promote this interface. We need an entity that has a single focus, no competing agenda, in order to connect credible climate information to those who need it, whether it is a city, a state, a climate services corporation, or a research manager.

I believe that a National Climate Service that is structured well and implemented effectively will dramatically increase our ability to respond to these challenges. The potential to serve our nation, I think, is enormous if we do this well.

Thank you for this opportunity, and I would be pleased to answer any questions when the time comes.

[The prepared statement of Dr. Barron follows:]

PREPARED STATEMENT OF ERIC J. BARRON

Chairman Baird, Ranking Member Inglis, and Members of the Subcommittee: Thank you for inviting me to testify on the importance of creating a National Climate Service. My name is Eric Barron, and I am the Director of the National Center for Atmospheric Research, a federally-funded institute based in Boulder, Colorado, that supports and conducts research and scientific inquiry into our atmosphere and

its interactions with the Sun, the oceans, the biosphere, and society. In all these areas, our scientists are looking closely at the role that humankind plays in creating climate change, increasing our ability to predict future changes, and assessing the impact that climate change is having, in turn, on us.

I am also Chairman of the Climate Services Coordinating Committee, a body within the Climate Working Group of NOAA's Science Advisory Board which formed last year to examine options for developing a National Climate Service. The Committee recently prepared a report titled *Options for Developing a National Climate Service,* which I would like to bring to your attention as a key document and resource on this topic. This report is intended to provide Members of this committee, other Members of Congress, and the new Administration, with a solid foundation on which to make well-reasoned choices on the development of a National Climate Service. At the core of the Report, we identify four options for developing a National Climate Service, weigh the pros and cons of each option, and list key recommendations for design and implementation.

I recommend that you review and take into consideration the findings and recommendations of *Options for Developing a National Climate Service.* It reflects the coordinated efforts, over the course of more than a year, of an authoritative group of climatologists, climate policy experts, federal policy-makers, potential users of a National Climate Service, and other key stakeholders. It is representative of a broad spectrum of interests from a range of sectors and backgrounds, all of which have a stake and should be taken into account in the integrated design of a National Climate Service.

The outcome of our Committee's efforts—distilled in the form of our report—offers an informed and well-considered analysis of how to best approach the design and implementation of a National Climate Service. I hope that, as you formulate policy ideas, and especially if you begin to draft an authorization bill for the National Climate Service, you will make ample use of our report, take advantage of our hard work, and use the members of the Coordinating Committee as resources.

Today, climate services—provided by a number federal agencies, universities, nonprofits, and private sector firms nationally—provide decision-makers with information about long-term trends in the weather and other Earth systems. While such climate services met some of user demand in the past, demand for climate information and the range of information that is needed are rapidly growing as decision-makers are increasingly concerned about the consequences of global warming: How should my community prepare? How can my community minimize losses? How can we maximize gain? Planners, commissioners, policy-makers, and other decision-makers want to know detailed and specific information about how climate change will affect their state, region, community, industry, or utility. They need a dependable and accurate source of information to which to turn. They need a level of engagement with experts that enables them to make informed decisions. They need a research community that recognizes and responds to their problems. The lives and the well-being of their clients and constituents are at stake, as are economic vitality of their communities and other priorities like environmental stewardship and sustainability.

The patchwork of climate services that currently exists does not have the capacity to meet growing needs and demands. Rather, climate services are disparate and disconnected by type and region, lacking central coordination, focus, and direction. They generally do not obtain data, predictions, and syntheses across a broad span of sectors and regions, nor do they have the resources to tackle the advanced computer climate modeling that is required to produce high-resolution, down-scale climate predictions. Currently, there is no single source of authoritative, credible and useful information that will allow society to span such important topics as the physical aspects of sea level rise, temperature and precipitation, the resource implications of failed crops, anticipating adverse human health outcomes, robust water supply, managing changes in ecosystems, or the social implications of migrations and resource competitions. In short, current climate services as they are presently constituted are not suited to new challenges or the rapidly growing demand for climate information.

As we face the certainty of a warming planet over the next 100 years—"unequivocal" in the words of the U.N. Intergovernmental Panel on Climate Change—a National Climate Service would dramatically increase our ability to respond, and it's necessary to unify, strengthen, and optimize our nation's existing climate services. The purpose of the National Climate Service would be to provide the best possible information to the public to assist in understanding, anticipating, and responding to climate, climate change, and climate variability, and their impacts and implications. Centralized within the Federal Government, integrated across region and type of services, and supported with sufficient resources and leadership, a National Cli-

mate Service would be unique in its capacity to produce and deliver authoritative, timely, and useful information on climate change. It would enable decision-makers to manage climate-related risks and opportunities, along with other local, State, regional, tribal, national, and global impacts.

A National Climate Service should:

1) promote active interaction among users, researchers, and information providers;
2) be user-centric, ensuring that scientifically-based information is accessible and commensurate with users' needs and limitations; and
3) provide usable information and enable the development of decision support tools through a sustained network of observations, modeling, research activities, and user outreach and assistance.

Critical to the survival and success of a new National Climate Service are the functions of design, leadership, and funding. These are addressed in the key recommendations laid out in *Options for Developing a National Climate Service,* the following five of which are critical to implement:

Recommendation #1. Internally Reorganize at NOAA. Given NOAA's mission and operational capabilities, it is an agency that should play a key role in the establishment and implementation of a National Climate Service. NOAA already contains many of the fundamental components of a climate service and they have considerable history in providing services to the Nation. However, as it is currently organized, NOAA is not well-suited to the development of a unified climate service function. An internal reorganization of NOAA that allows greater connectivity between weather and climate functions, and between research, operations, and users, is a necessary step for success.

Recommendation #2. Define Role of Each Agency. There are several federal agencies that are positioned to contribute expertise and that must contribute resources to support a National Climate Service. Each federal agency needs to collaboratively define its role and level of commitment in a National Climate Service. To achieve success, each agency must commit a set amount of funding that is not optional and must commit to participation at a very high level within the agency. There are examples of interagency programs that have failed because leadership was not involved and participants did not have the authority to make commitments on behalf of their agency. This service is too important to the security and well-being of the country to risk that approach. We must also define a lead federal entity. There is also good logic for considering NOAA as the lead agency. A lead agency provides a greater ability to speak with an authoritative voice, and a NOAA-lead allows us build quickly from existing components of a climate service, ensure support of inherently governmental functions (observing systems, operational systems), and increases our ability to ensure "one-stop shopping" if weather and climate functions are integrated.

Recommendation #3. Place under High-Level Leadership. Success of a National Climate Service requires recognized, clear, authoritative, responsible leadership within the Federal System at the highest level possible, ideally within the White House. The importance of this cannot be overemphasized. The service must be interagency and involve State and local governments as well as the private and public sector. To make this work, someone with clear and obvious authority must take the lead.

Recommendation #4. Grant a Large, Dedicated Budget. A National Climate Service requires a defined, independent budget large enough to influence the direction of the Service and achieve its mission.

Recommendation #5. Establish a Federated Structure. A National Climate Service requires an interface best described by a federated structure (i.e., non-profit or federation). This point is extremely important. The greatest strengths of the federated or non-profit option is their flexibility and nimbleness (especially the non-profit option), ability to connect and actively engage a broader range of users and members of the research community, and potential to have a single focus (no competing agenda).

Implementation of the recommendations outlined in the report will establish an efficient and effective service that promotes interactive partnerships among scientists, information providers, and a variety of users. For instance, accurate and properly-scaled predictions of long-term trends in wind volume and sunshine levels at a research institution can help renewable energy companies plan where to build

their new wind turbine farm or concentrated solar thermal plant. A national clearinghouse for all carbon and climate monitoring data and all impact analyses, based in Washington, D.C., could support policy-making and provide an authoritative signal to Congress about how rapidly and deeply you should cut or mitigate greenhouse gas emissions to minimize losses. A civil engineer's high-resolution model of how streamflow will change over the long-term for a key river could help fisherman improve management of that river's fisheries, farmers improve irrigated agriculture along the river, and dam operators optimize hydropower production. And authoritative information on weather and climate parameters associated with causes of adverse health outcomes could help officials at the Center for Disease Control and Prevention and other health professionals respond to adverse health outcomes in advance and prepare with an appropriate level of medical community preparation.

As these examples show, the benefits of a National Climate Service will be manifold, will extend to all parts of the economy, and will have implications for the everyday lives of all people of this country. Climate change is happening now and it is occurring at a faster rate than anticipated. We need a National Climate Service that will enable people to plan for change in a constructive, efficient manner. If we succeed in this endeavor, I am confident that we can avoid many of the adverse changes that could surely affect our society otherwise.

Mr. Chairman and Ranking Member Inglis: Thank you again for the opportunity to testify before your Subcommittee regarding this very important program. I would be more than happy to field any questions you or the other Members of the Subcommittee have for me today.

BIOGRAPHY FOR ERIC J. BARRON

Eric J. Barron, Director of the National Center for Atmospheric Research (NCAR), began a career in geology with an undergraduate degree from Florida State University (1973). After obtaining his Master's degree in oceanography, marine geology and geophysics from the University of Miami (1976), his interest turned to climate studies with a Cray Supercomputing Fellowship at NCAR. Upon completing his Ph.D. in oceanography from the University of Miami (1980), he returned to NCAR as a postdoctoral research fellow and then continued as a research scientist in the global climate modeling group. In 1986 Barron went to Pennsylvania State University to direct the College of Earth and Mineral Sciences' newly formed Earth System Science Center (ESSC), and was promoted to Professor of Geosciences in 1989. Under Barron's leadership, the growth of ESSC resulted in the establishment of the College of Earth and Mineral Sciences' Environment Institute, encompassing the ESSC and a group of other research center. Barron became the Director of this new institute in 1998 and earned the title of Distinguished Professor in 1999. In 2002 he was named Dean of the College of Earth and Mineral Sciences at Penn State. Prior to coming to NCAR in July 2008, Barron served as Dean of Jackson School of Geosciences at the University of Texas at Austin.

Barron's research interests are in the areas of climatology, numerical modeling, and Earth history. During his career, he has worked diligently to promote the intersection of the geological sciences with the atmospheric sciences and the field of Earth system science. He served as Chairman of the Climate Research Committee of the National Research Council (NRC) from 1990 to 1996. In 1997, he was named Co-Chairman of the Board on Atmospheric Sciences (BASC) of the NRC, and since 1999 he has chaired the BASC. Additional NRC panels on which Barron has served include the Committee on Global Change Research, the Assessment of NASA Post-2000 Plans, Climate Change Science, the Human Dimensions of Global Change, the Panel on Grand Environmental Challenges, and the Committee on Tools for Tracking Chemical, Biological, and Nuclear Releases in the Atmosphere: Implications for Homeland Security. In addition to serving on the National Research Council, Barron chaired the Science Executive Committee for NASA's Earth Observing System and NASA's Earth Science and Applications Advisory Committee (ESSAC). He has also served as Chairman of the USGCRP Forum on Climate Modeling, the Allocation Panel for the Interagency Climate Simulation Laboratory, the U.S. National Committee for PAGES and the NSF Earth System History Panel.

Barron is a fellow of the American Geophysical Union, the American Meteorological Society, the Geological Society of America, and the American Association for the Advancement of Science. In 2003, he received the NASA Distinguished Public Service Medal.

Chair BAIRD. Thank you. Dr. Mote.

STATEMENT OF DR. PHILIP W. MOTE, DIRECTOR, OREGON CLIMATE CHANGE RESEARCH INSTITUTE AND OREGON CLIMATE SERVICES, OREGON STATE UNIVERSITY; PROFESSOR, COLLEGE OF OCEANIC AND ATMOSPHERIC SCIENCES

Dr. MOTE. Thank you, Chairman Baird and Ranking Member Inglis, and Members of the Committee. I am still with the Climate Impacts Group at the University of Washington for a couple more months, in addition to my responsibilities with the Oregon Climate Change Research Institute. And at the University of Washington, I also serve as State Climatologist, and I am pleased that you all have Nolan Doesken, the President of the AASC, to speak in a few minutes.

I have been invited here to speak on behalf of the nine university-based, regionally focused research teams known as RISAs, which Dr. DeGaetano already mentioned. RISA stands for Regionally Integrated Sciences and Assessments, and they are supported by NOAA's Climate Program Office. Most of the RISA teams have contributed to my oral and written testimony.

RISAs have been providing climate services, since the first RISA, our own Climate Impacts Group at the University of Washington, was established in 1995 by Ed Miles. Indeed, our group, with Ed as lead author, wrote a paper on national climate services, published in 2006, that helped start the current discussion about climate services.

Climate services provide the use-inspired climate science needed to support decisions that plan for and cope with climate variability and change. With steady progress in science, vigorous growth in demand for actionable climate information, and the urgency of coping with a changing climate, the time for a National Climate Service has arrived.

Selecting from dozens of possible examples, I provide here a few examples of climate services that the RISAs provide, focusing for brevity on water resources. Early on, the Northwest and Pacific RISAs helped agencies like Seattle public utilities and Pacific Island water resource managers apply seasonal forecasts to estimates of water supply. Western and Southeastern RISAs have engaged in drought planning and monitoring and post-drought analysis. CLIMAS, the Southwest RISA, worked with State agencies in Arizona on the Arizona Drought Preparedness Plan. The RISA in the Carolinas developed a drought monitoring tool to monitor low flow triggers.

Looking decades into the future, RISA scientists analyzed the effects of climate change on the small rivers that supply urban needs, like the Cedar River for Seattle, and on the large basins, the Columbia and the Colorado, for example. Such projections are now routinely being used in long-range planning by municipal and State governments, in partnership with RISAs, as in California, Colorado, and Washington. Western RISAs have worked for a number of years with the U.S. Bureau of Reclamation and others to understand uses of climate information.

These and other examples illustrate the importance of the partnerships that RISAs have with NOAA offices and other federal agencies, Regional Climate Centers, State climatologists, extension, tribes, State and local governments, NGOs, and the private sector.

Each of these partners has unique contributions, perspectives, and responsibilities. The RISAs, based at universities, emphasize user-oriented research and outreach.

In a National Climate Service, user-oriented research would be vital, and RISAs would play a critical role. Here is an example of what an NCS could accomplish. Redrawing floodplain maps with a rigorous assessment of how climate change may be changing the flood risk, also known as the hundred year flood. Federal labs provide climate model outputs. University researchers run hydrologic models. Political science experts craft flexible policies to incorporate local concerns. RISAs and State climatologists and extension services engage emergency managers, land use planners, and so on.

Climate services are already provided in various forms by the nine RISAs, by Regional Climate Centers, private consultants, State climatologists, and so on, but the efforts fall short of what is needed. For one thing, the RISA program needs to be expanded to serve all fifty states, plus the territories. And funding for the RISA program is so thinly stretched now that we cannot meet user demand.

Building on the 2001 NRC report, the RISAs came up with ten key elements that we believe will be critical to an effective NCS. I have condensed it to five for brevity.

Number one, needs of stakeholders must be foremost, and are best understood at the regional scale. Two, NCS must recognize that decision contexts need climate information and much more. Three, because capability must span a range of space scales, implementation must be national, but with strong regional and State components, including universities, to assist regional and State level decisions. Four, NCS design should be flexible and evolutionary, and be built around effective partnerships. Five, NCS success requires that an effective larger national and international climate science enterprise, including observations, exist to support it.

The RISAs show that regional university/federal partnerships can make unprecedented progress in providing climate services, and we succeed because we are backed up by a world-class federal science enterprise. Climate knowledge, properly used and conveyed, will help Americans deal with, and indeed prosper, in the face of future climate variability and change.

Thank you for your time.

[The prepared statement of Dr. Mote follows:]

PREPARED STATEMENT OF PHILIP W. MOTE

I have been invited here to speak on behalf of the nine university-based, regionally-focused research teams known as RISAs. RISA stands for Regionally Integrated Sciences and Assessments, supported by NOAA's Climate Program Office. Most of the RISA teams have contributed to my oral and written testimony.

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Climate services provide the use-inspired climate science needed to support decisions that plan for and cope with climate variability and change. With steady progress in science, vigorous growth in demand for actionable climate information, and the urgency of coping with a changing climate, the time for a national climate service has arrived.

Selecting from dozens of possible examples, I provide here a few examples of climate services RISAs provide, focusing for brevity on water resources. Early on, the

Northwest and Pacific RISAs helped agencies like Seattle Public Utilities and Pacific island water resource managers apply seasonal forecasts to estimates of water supply. Western and southeastern RISAs have engaged in drought planning and monitoring, and post-drought analysis. CLIMAS (the southwest RISA) worked with State agencies in Arizona on the Arizona Drought Preparedness Plan. The RISA in the Carolinas developed a drought monitoring tool to monitor low-flow triggers. Looking decades into the future, RISA scientists analyze the effects of climate change on small rivers that supply urban needs, like the Cedar River for Seattle, and on the large basins of the Colorado and Columbia Rivers. Such projections are now routinely being used in long-range planning by municipal and State governments in partnership with RISAs, as in California, Colorado, and Washington. Western RISAs have worked for a number of years with the U.S. Bureau of Reclamation and others to understand uses of climate information.

These and other examples illustrate the importance of partnerships RISAs have—with NOAA offices and other federal agencies, with regional climate centers, State climatologists, extension, tribes, State and local governments, NGOs, and the private sector. Each has unique contributions, perspectives, and responsibilities—RISAs, based at universities, emphasize user-oriented research and outreach. In a National Climate Service, user-oriented research would be vital and RISAs would play a critical role. An example of what an NCS could accomplish: redrawing flood plain maps with a rigorous assessment of how climate change may be changing flood risk, a.k.a. the 100-year flood. Federal labs provide climate model output, university researchers run hydrologic models, political science experts craft flexible policies to incorporate local concerns, RISAs and State climatologists engage emergency managers, land use planners, and other local officials.

Climate services are already provided in various forms by the nine RISAs, by regional climate centers, private consultants, State climatologists, extension, the National Weather Service, and others, but the efforts fall short of what is needed. For one thing, the RISA program needs to be expanded to serve all 50 states plus the territories. And funding for the RISA program is so thinly stretched that we cannot meet user demand.

Building on a 2001 NRC report, the RISAs came up with ten key elements that we believe will be critical to an effective National Climate Services (NCS); I've condensed it to five for brevity.

1. Needs of stakeholders must be foremost, and are best understood at the regional scale.
2. NCS must recognize that decision contexts need climate information and much more.
3. Because capability must span a range of space scales, implementation must be national but with strong regional and State components, including universities, to assist regional and State-level decisions.
4. NCS design should be flexible and evolutionary, and built around effective partnerships.
5. NCS success requires that an effective larger national (and international) climate science enterprise, including observations, exists to support it.

The RISAs show that regional university-federal partnerships can make unprecedented progress in providing climate services, and we succeed because we are backed up by a world-class federal science enterprise, a global climate observing system, data centers, and global and regional climate modeling. Climate knowledge, properly conveyed and used, will help Americans deal with, and indeed prosper, in the face of future climate variability and change. Thank you for allowing me and my colleagues to share our thoughts with your subcommittee today.

Executive Summary

NOAA's Regional Integrated Science and Assessments (RISA) program consists of nine teams focused on different climatically-sensitive regions of the United States. These teams have developed innovative *place-based, stakeholder-driven research, partnership,* and *services* programs over the past decade, and in doing so, have created an effective demonstration-scale climate service for parts of the Nation. The experiences of the RISA programs and their successful development of decision support tools and other products indicate that the following key elements will be critical to an effective National Climate Services (NCS):

1. NCS must be *stakeholder (user)—driven,* and accountable to stakeholders.
2. NSC must be based on *sustained regional interactions* with stakeholders.

3. NCS must include efforts to improve *climate literacy,* particularly at the regional scale.
4. *Multifaceted assessment* as an ongoing, iterative process, is essential to NSC.
5. NCS must recognize that stakeholder decisions need climate information in an *interdisciplinary context that is much broader than just climate.*
6. NCS must be based on effective *interagency partnership*—no agency is equipped to do it all.
6. Implementation of NCS must be *national, but the primary focus must be regional, where decisions are made.*
8. Capability must span a range of space and time scales, including *both climate variability and climate change.*
9. NCS design should be *flexible and evolutionary, and be built around effective federal-university partnership.*
10. NCS success requires that an effective regional, national and international *climate science enterprise, including ongoing observations, model simulations and diagnostics,* exists to support it.

Prepared through a collaborative effort *of* RISA partners, this document reviews literature in support of the RISA approach, and provides several examples of RISA efforts that illustrate these ten key elements, focusing on water resource, wildfire, and agriculture. Moreover, during the past 10 years, droughts in the western and the southeastern U.S. have illustrated the value and utility of RISA teams in diagnosing and predicting droughts, and in designing drought mitigation and preparedness plans. Such efforts arise from the interdisciplinary and collaborative nature of the RISAs, and provide a template for NCS. Scaling up the RISA experience into an NCS poses organizational challenges, but offers numerous important lessons, as well as the promise of success.

1. Introduction

Climate services are intended to provide the use-inspired climate science needed to support decision-making in society, particularly as it relates to anticipating, planning for, and dealing with climate variability and climate change. Owing to steady progress in climate science and vigorous growth in public demand for actionable climate information, the motivation for rapid expansion of climate services has never been greater. Climate information includes paleoclimate (reconstruction of past climate from proxies like tree rings); statistics about means and extremes from instrumental data and interpretations thereof; seasonal climate forecasts; projections of global and regional climate change; and much more. Climate services are already provided in various forms by the NOAA Regional Integrated Sciences and Assessments (RISA) program through its nine regional groups, by regional climate centers, private consultants, State climatologists, the National Weather Service, and others. This document describes the experiences of the RISA program for input as the Nation contemplates the design and implementation of a National Climate Service (NCS).

Basic research in climate dynamics, as well as efforts to observe and predict the Earth system, have paid immense dividends in improved weather forecasts, seasonal climate predictions, and responses of global climate to external forcing like greenhouse gases or volcanic eruptions. Climate services connect these advances to specific decision environments, much the way the National Weather Service implements new research in an operational, decision-relevant setting. A fundamental aspect of this connection is a responsiveness to users' needs. It is this responsiveness that is at the heart of the RISA success in understanding how climate information is interpreted and used by a wide range of stakeholder decision-makers.

The RISA program supports integrated, place-based research across a range of social, natural, and physical science disciplines to expand decision-makers' options in the face of climate change and variability at the regional level. RISA teams are comprised of researchers from the physical and natural sciences, engineering, economic, legal, and social sciences who work together and partner with stakeholders in a region to determine how climate impacts key resources and how climate information could aid in decision-making and planning for those stakeholders. It opens new conduits for the flow of information and documents innovative practices for providing services that can lead to improvement across the whole climate services enterprise. The significant RISA success in meeting user needs illustrates the power of regional stakeholder-driven interdisciplinary climate research as a complement to the more operational, national-scale support provided by federal agencies such as NOAA.

In this document we briefly review some relevant history of climate services, describe key elements of climate services, provide examples based on the RISA experience, and offer some thoughts about implementing National Climate Service informed by the RISA experience.

2. RISA Teams and Background Literature

The network of RISA teams (Figure 1) represents a significant body of experience and knowledge about climate services needs. Each RISA developed independently and defined its own approaches to meeting stakeholder demand. Since the first RISA was established in the Pacific Northwest in 1995, the network has expanded to nine teams, each of which has long-term relationships with users of climate information from a wide variety of sectors, levels of government, and regions. RISAs work closely with these users to identify and address needs including climate literacy, fundamental use-inspired and applied research, and development of decision-support tools.

A critical element of the regional focus is the intense, sustained contact with users that is necessary to uncover, assess and refine the ways in which climate services can best meet user needs. These efforts often break new ground as they respond to the research and support needs of regional user groups. Some specific RISA efforts have also delved more deeply into cross-scale issues examining a local situation, a sector, or multi-jurisdictional area within a regional context. The efforts have generated many lessons on climate needs, as well as best practices in effective development and delivery of services. RISAs have also had success in the development and transfer of information prototypes, applications, service innovation, and research methodologies. With time, RISAs have also begun to collaborate more regularly with each other, as well as other regional climate science partners.

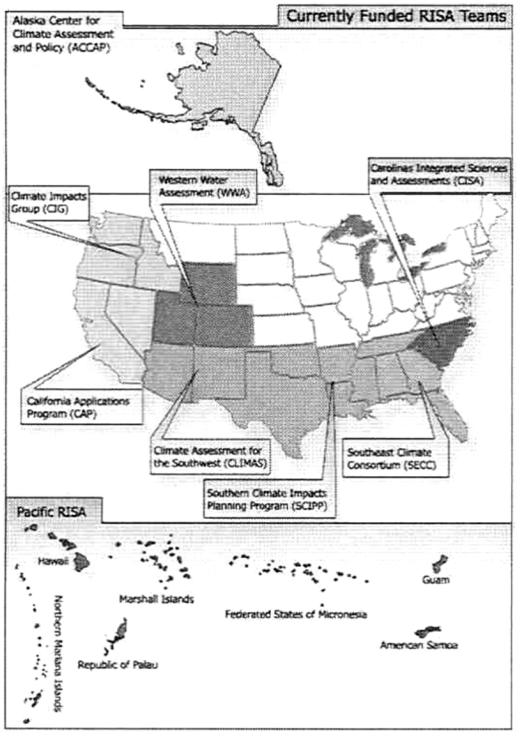

Figure 1. The nine RISA teams.

In the meantime, a steady drum beat of published statements have stressed the need for a coordinated approach to climate services. In 2001 the National Research Council issued a report called *A Climate Services Vision: First steps toward the future* (NRC, 2001). The report highlighted that the societal value of climate information is dependent upon many factors, including the:

- strength and nature of linkages between climate, weather, and human activities;
- nature of uncertainties associated with forecasts;
- accessibility of credible and useful climate information by decision-makers;
- ability of users and providers to identify each other's needs and limitations; and
- ability of users to respond to useful information.

According to the NRC report, addressing these factors requires research, data stewardship, product development, and education programs.

The NRC report also outlines five "guiding principles" for the development of a new climate services effort:

(1). The activities and elements of climate services should be **user-centric**—the user community is diverse, with a wide range of space and time scales needed. Users are becoming increasingly diverse and knowledgeable, with a commensurate increase in specialized needs. In order to address these needs, evaluation, mutual information, and feedback are needed to improve communication and accessibility of information.

(2). If a climate service function is to improve and succeed, it should be supported by **active research,** and research is needed not just on the fundamentals of climate variability and change, but also on diffusion of knowledge and information. This requires mission-oriented research with active mechanisms to transfer knowledge from research to useful products.

(3). Advanced information (including predictions) should be provided on a **variety of space and time scales,** and in the context of the historical record, in order to understand natural variability and climate change. Predictions should be accompanied by analysis of probabilities, limitations, and uncertainties. Causes and character of natural variability should be described. Continuous, accurate, and reliable historical climate observations are needed at diverse locales, and products need to be provided for scales from local to global.

(4). The climate services knowledge base requires **active stewardship**: observations must be reliable, freely exchanged, and accessible. This requires open and free exchange of data, combining observations into useful, multi-purpose records, and assuring synergism between observations, theories, and models. All of this should be driven by a "robust and easily accessible delivery system."

(5). Climate services require **active and well-defined participation by government, business, and academe.** Each of these players has important roles in providing climate services. The government should be motivated by "public goods and services," which they describe as non-rival and non-exclusive. These are products that are of a general nature, not for individuals or individual commercial operations. Government should also take the lead role in maintaining the official climate records. The private sector should use the data to meet basic and applied research needs of its users. Academic research organizations should focus on their central mission of research, education, and outreach. Sometimes this may include research data and analysis and product development in partnership with industry or government towards meeting these goals.

The NRC recommendations were presented in three sections: (1) promoting more effective use of the Nation's weather and climate observation systems; (2) improving the capability to serve the climate information needs of the Nation; and (3) interdisciplinary studies and capabilities needed to address societal needs. Recommendations 1 and 2 of the NRC report focus primarily upon the infrastructure and provision of routine services. While the RISAs contribute to these goals, their most notable successes occur in Recommendation 3, which can be elaborated as:

- Develop regional enterprises designed to expand the nature and scope of climate services;
- Increase support for interdisciplinary climate studies, applications, and education;
- Foster climate policy education; and

- Enhance the understanding of climate through public education.

The report describes a service system that "should strive to meet the needs of a user community at least as diverse and complex as the climate system itself, ranging from the international community to individual users, and involving both the public and private sectors. Central to the scope of a climate service is the need to embrace wide ranges of time and space scales because decision-making occurs on all scales from local to global and from weeks to centuries."

Since 2001, several reports have highlighted the critical role that RISAs provide through their research and service. A 2003 forum of the American Meteorological Society focused on "Improving Responses to Climate Predictions," emphasized the need for more "science integrators" (Greenfield and Fisher, 2003). Finding 5 of the forum notes that "climate information is most effectively developed and applied through **partnerships between climate information providers and decision-makers**." The report also notes the importance of evaluation of risks and benefits as a factor encouraging use of climate forecasts.

Miles et al. (2006) provided a perspective on climate services linking the international aspects of climate monitoring, research and modeling to regional applications of climate information. Based in large part on the success of the Climate Impacts Group (the Northwest RISA), they stressed that regional organizations were a key component in successful delivery of climate services within the context of an NCS.

In a review of the Climate Change Science program, the *National Research Council* (2007) noted that "discovery science and understanding of the climate system are proceeding well, but **use of that knowledge to support decision-making and to manage risks and opportunities of climate change is proceeding slowly**." The report emphasized the smaller spatial scales at which decisions are made and the need for improved understanding of the impact of climate changes on human well-being and vulnerabilities. The review called for stronger connections with social science researchers and a more comprehensive and balanced research program, including human dimensions, economics, adaptation, and mitigation. The report again highlights RISA as a positive example: "NOAA's Regional Integrated Sciences and Assessments program has been effective in communicating research results to stakeholders in particular sectors . . . or regions, but this program is small and has limited reach . . . Building and maintaining relationships with stakeholders is not easy and requires more resources in the CCSP Office and participating agencies than are currently available. Yet a well-developed list of stakeholders, target audiences, and their needs is essential for educating the public and informing decision-making with scientifically-based CCSP products."

In 2007, the Western Governors' Association and Western States Water Council suggested that **improving relationships between State agencies, academia and federal climate science agencies** was the most critical action on improving State and regional response to climate variability and change (CDWR, 2007). RISA was again highlighted as a "successful step to a bridging effort between the research community and practitioners" and they recommended that the program be expanded.

The maturation and expansion of the RISA Program has contributed to the body of knowledge about how climate information is conveyed, received, and utilized by key stakeholder groups. These findings should be used to construct improvements in the products and services provided by federal agencies and State climate office services. Within the NOAA Climate Program Office, programs such as Transition of Research Applications to Climate Services and the Sector Applications Research Program have supported research geared toward better understanding of how stakeholders use climate information. These studies are often at a regional, State or local level, allowing each study to capitalize upon unique circumstances to the area. For example, the RISA-served areas of the country with a strong response to El Niño-Southern Oscillation (ENSO), namely the Pacific Islands, Northwest, California, Southwest, and Southeast, can make use of seasonal predictions; whereas for the parts of the country with lower seasonal predictability, the utility of seasonal forecasts may be low.

A common theme in these reports is that rapid growth in demand for climate services have converged with growth in knowledge of climate and of human interactions, and with technological advances including communication networks, to pave the way for a **transformation of climate services.** They envision the emergence of a broader, organized, and sustained climate service that addresses multiple environmental challenges.

3. Essential elements of a National Climate Service

Drawing on collaboration and shared experiences, the RISA teams have summarized our reflections on the essential elements of a National Climate Service (Table 1). These include elements that are essential when working with user groups, as well as implications for institutional design.

Table 1. Essential Elements of an NCS

1. NCS must be stakeholder (user) – driven, and accountable to stakeholders
2. NSC must be based on sustained regional interactions with stakeholders
3. NCS must include efforts to improve climate literacy, particularly at the regional scale
4. Multi-faceted assessment as an ongoing, iterative process, is essential to NSC
5. NCS must recognize that stakeholder decisions need climate information in an interdisciplinary context that is much broader than just climate
6. NCS must be based on effective interagency partnership – no agency is equipped to do it all
7. Implementation of NCS must be national, but the primary focus must be regional, where decisions are made
8. Capability must span a range of space and time scales, including both climate variability and climate change
9. NCS design should be flexible and evolutionary, and be built around effective federal-university partnership
10. NCS success requires that an effective regional, national and international climate science enterprise, including ongoing observations, model simulations and diagnostics, exists to support it

3.1 A stakeholder-driven perspective

A national climate service must prioritize stakeholder needs and support services based on their *usefulness* in addressing those needs. Critical climate service needs vary among regions depending on vulnerabilities and how planning and policy decisions consider local climate conditions such as drought, wildfire, snowpack depth, ice storms, storm frequency, the likelihood of heat waves, or the impact of ocean temperatures on fisheries. The climate science enterprise currently addresses these issues, but as the NRC report *Decision-Making for the Environment* (2005:26) points out, approaches to framing research questions and data analysis often mean that "when science is gathered to inform environmental decisions, it is often not the right science." A user-centric approach, which is more likely to gather the "right science," affects the design of research, models, and observation systems to support fundamental use-inspired and applied research, and extends to new communication and operations standards. The timeliness of information availability is also critical to its utility—decision calendars vary by region, and climate services will need to be timed to provide the best information at most useful times.

3.2 Sustained, ongoing regional interactions with users

From El Niño events in the 1980s, to global climate change today, stakeholder interest in climate science has grown rapidly. In order to provide relevant information, RISAs have demonstrated that users and scientists committed to innovation in this area must make a sustained commitment to learning from each other about climate science and about the equally complex sectoral decision needs—the processes, vulnerabilities, goals, constraints, calendars, and capabilities—that influence the value, utility, and availability of climate information. Stakeholders are seeking trusted sources to help them understand a new set of issues characterized by rapidly evolving science, uncertainties, and highly politicized controversies. Ongoing engagement is necessary to build and maintain the credibility required of a national climate service, and to respond flexibly to rapidly evolving stakeholder needs and capabilities.

Implicit in making climate services stakeholder-driven, and based on sustained stakeholder partnerships, is the fact that the enterprise must be inherently regional in nature. National entities cannot succeed without strong regional presence and partnership. The RISA success has been built on the regional strengths of universities and their well-established ability to partner in a sustained way in their regions, and to do so in a way that cuts across disciplinary, agency, and sectoral boundaries.

3.3 Broad efforts to improve climate literacy

Many decision-makers are already hearing and heeding calls to use climate information as part of accountability and disclosure from regulators, constituents, or clients. For decision-makers to use climate information in an effective manner, they often must have at least a rudimentary understanding of the strengths, limits, and availability of good climate information and services. For example, seasonal forecasts are often expressed as shifts in probabilities, whereas users often reduce these forecasts to the simpler notion of "above average." Many users are in the early stages of learning about general climate issues, whereas others are interested in more sophisticated treatment of topics related to specific professional or occasionally personal interests. RISA experiences indicate that both sophisticated and casual users of climate information want to relate general processes (e.g., global warming or El Niño) to local/regional experience, expectations, and concerns, and vice versa. When users understand the statistical and physical reasoning of climate sciences, and how to evaluate the plausibility of an explanation or the validity of a seasonal forecast, they can make better use of climate information. They can also be a more active partner in driving the needed science and services. One of the most effective ways to improve society's resilience to climate variability and change is through greater climate literacy.

3.4 Assessment as an multifaceted, ongoing, and iterative process

Several types of assessment are integral to a successful climate services. At one end of the spectrum, climate services must assess—at regular intervals—the state of the climate system, the state of climate understanding, and the range of potential climate impacts, risks and vulnerabilities that might occur. This is akin to the assessment approach employed by the Intergovernmental Panel on Climate Change. In addition, advances in climate science and the changing dynamics of socioeconomic systems require that the needs of stakeholder decision-makers also be assessed in an ongoing, iterative manner, just as the effectiveness of all climate service methodologies and activities must be routinely assessed and improved. These latter types of assessment are best implemented via social science research.

Growing populations, shifting economic sectors, greater reliance on new energy sources, changing demands on water and on other critical resources, are but a few of the trends that will alter the character of known vulnerabilities and stakeholder needs. Changing patterns of threats and hazards, and emerging issues like re-engineering California's San Francisco Bay and Delta system, ocean dead-zones and acidification, will require regular investigation of patterns of risk and vulnerability to inform decision-making (Healy, Dettinger and Norgard, 2008; Dettinger and Culberson, 2008). For all of these reasons, assessment must be addressed as an iterative process, and all aspects of the climate service enterprise must learn from these assessments. Ongoing assessments at regional scales will improve conditions and decision-making at those scales while also, in composite, providing a better grounding for decisions, adaptation and mitigation by the Nation as a whole.

3.5 Stakeholder decisions need climate information and much more

Decisions that could benefit from climate information typically also have inputs from other types of environmental and societal information. A National Climate Service must address critical interfaces of climate variability and change with societal decision-making and adaptation across scales and sectors. For example, coastal communities concerned about projections of sea level rise and variability in frequency and intensity of storms, also need to worry about municipal bond ratings, availability of insurance, and impacts of local coastal erosion processes. Water utilities evaluating strategies for dealing with projected changes in drought frequency, intensity, and duration, must make their decisions in the context of aging infrastructure, projections of population growth and demand, the efficacy of water conservation strategies, future energy requirements, ecological constraints and the flexibility of regulatory frameworks. To meet these interdisciplinary needs, an NCS must provide services that are useful in the context of socioeconomic and environmental decision-making—e.g., decision support tools—that in turn requires developing both (a) much closer interactions between climate science and other intellectual disciplines and (b) closer coordination of climate information with socioeconomic and environmental impact models.

3.6 Interagency partnership is essential

The capacity to address the broad scope of activities and goals affected by climate is distributed across federal, State and local agencies where experienced staff, tools, and skill sets as well as a deep understanding of the policies, procedures, and regulations have been developed over decades. In particular, *a federal-level interagency partnership* is needed to ensure that climate services support the integration of appropriate climate information with non-climatic information, and also enable users to make decisions in cross-agency jurisdictional frameworks. Specialized insights into sectoral capacity, key institutional challenges, major regulatory issues, research needs, critical uncertainties, and potential interactions among climate, social, economic, and ecological systems is critical to successful adaption involving multiple complex systems and avoiding maladaptive choices and unexpected consequences.

3.7 Implementation must be national in scope, but regional in focus

Ultimately, NCS should be capable of providing both regionally specialized products and equivalent quality services to all parts of the country. Brief consideration of the contrasts among the Pacific Islands, the small, highly variable New England States, the arid, rapidly growing Southwest, and the climatically vast State of Alaska, highlights the formidable scale of the task. The distinctive regional character of environmental and climate processes and science challenges, as well as regional-distinct vulnerabilities, decision-making processes, adaptation issues, and the value of close engagement with stakeholders, all indicate that many of those services will be most effectively designed and delivered through a regional focus. To achieve equity in coverage, many regional issues will require regionally-explicit approaches to meet specific observation and research needs, or to assess the complex interactions of human and natural systems in a place.

Regional texture in dominant issues, climate-sensitive sectors, policy context, and dominant climate processes require regionally specific information, not just higher spatial resolution. National implementation of a regionally focused climate service can ensure that shared regional needs (e.g., large-scale observing systems, modeling and basic research on continental to global-scale processes) are addressed in an efficient manner, and that lessons learned in one region can benefit another. A national scope also addresses the interconnectedness of climate-sensitive sectors in which information about drought, crop productivity, or snowfall in another region can be as important as local information: for example, energy supply in California is closely related to snowpack (and hence hydropower production) in the Northwest. Agricultural production in one region can often be optimized with information about trends throughout the country. In order to meet demands for climate services for national-scale needs, regional findings must be inter-comparable and amenable to national-scale compilations, thus requiring national scale equivalency of quality and (to some extent) methods.

3.8 Capability must span a range of space and time scales

Decision contexts often require information on a range of timescales in one location, for example, water supply planning can integrate timescales from one to forty years, or longer. The demand for climate services will continue to come from nested spatial and temporal scales in which each of the levels plays a role in increasing overall societal resilience, so NCS must be able to span these scales. Notably, RISAs

have repeatedly identified decadal scale variability as an area of unexpected and, to date, under-addressed importance to stakeholders as they plan, scope and design long-term infrastructure investments and adaptations to climate variations and change.

A successful climate service must also cover both climate variability on seasonal to centennial timescales, as well as climate change. Decision-makers often need information and support that integrates across both near-term and long-term decision scales. Ideally, climate services also integrate seamlessly with weather. In the real world, all variations in the environment, whether natural or human caused, have to be dealt with.

3.9 Program design should be flexible and evolutionary—universities are key

Climate service is a relatively young endeavor that requires greater capacity in new areas to address dynamic areas of knowledge and rapidly expanding—and changing—user needs. In just the past decade, stakeholder needs have grown much more sophisticated and have expanded from a focus on seasonal forecasts to an integrated interest in climate change projections, paleoclimate, and inter-decadal outlooks. Recent droughts, wildfires, levee failures, and insect outbreaks have prompted calls to understand the nature of these threats and to inform strategies to increase social, economic, and ecological resilience. Many such climate-related events have limited public issue-attention cycles and "windows of opportunity" when constituents, victims, and policy-makers are focused on addressing an event or issue. A NCS will need to continually prepare, anticipate, evolve, and then be quick on its feet to be judged successful in meeting those periods of intense, focused demand. Successful climate services must maintain the ability to translate and apply new science and to anticipate and fulfill evolving research and information needs. Effective climate services must be able to learn and change.

The RISA program has proven the merits of using innovative and strong federal-university partnerships to develop and provide climate services. Table 2 highlights some of the key capabilities that universities provide, and the RISAs have demonstrated how universities are uniquely able to understand regional issues, build and maintain regional science and stakeholder partnerships, provide the needed interdisciplinary contexts, rapidly shift foci in response to new stakeholder need, educate, and work with private-sector partners. RISAs have also shown how university teams are ideally configured for interdisciplinary research, for developing prototype service methodologies and products, and for working with operational organizations (e.g., federal agencies) to transition these services into operations. Universities also have a long tradition of working with federal partners to develop national-scale observing, modeling and research programs.

Table 2. Key Climate Service Capabilities Provided by Universities

1. A majority of the nation's climate science expertise, including expertise on regional climate dynamics and influences
2. A tradition of trusted regional stakeholder partnerships (especially at land- and sea-grant institutions),
3. The needed interdisciplinary expertise - (e.g., climate science, social science, ecosystem science, policy, law, and economics),
4. The social science capability needed for needs, performance and other assessment,
5. Proven ability to work simultaneously with multiple federal, state and local agency partners,
6. A flexible project workforce that can shift rapidly as stakeholder needs evolve,
7. The best framework for educating and training stakeholders and the next generation workforce,
8. Proven entrepreneurship, development of new climate observations, technology-transfer, and private sector partnership capacity.

3.10 Climate services rely on a larger climate science enterprise

In designing and implementing a national climate service, there may be an inclination to include all climate science activities under the rubric of climate services. Certainly, climate services rely on quality observations, modeling, and research, much of which requires vastly more resources than any NCS effort can provide on its own. Regionally-focused observation, research, and modeling efforts may be sensibly included within climate services (and at universities), but where to draw the line between NCS and national or global climate science that supports NCS? Should global satellite observation programs be included? The modernization of the Historical Climate Network? The USGS stream gauge network? Global climate model inter-comparison efforts? The importance of all of these examples goes beyond just regional climate service, and design of a NCS needs to include mechanisms for determining what is within or outside NCS institutionally and financially. At the same time, it is critical that mechanisms be developed that allow the climate service to influence other elements of the national climate-science enterprise to ensure it is responsive to stakeholders and useful to the Nation. Separating NCS from other climate science activities recognizes the importance of these other activities, and allows NCS champions to identify and advocate for the whole breadth of climate science.

4. RISA Experiences in Climate Service

Some examples of climate services developed by RISAs illustrate the ten essential elements just discussed. These examples are not intended to be a comprehensive catalogue of each RISA's activities, nor do they reflect the level of accomplishment of each RISA. Although the examples below emphasize the work of the mature RISAs, it is worth highlighting that the new RISAs also provide illustrations of the ten essential elements. The examples cover some of the research topics that span several of the RISAs—water, agriculture, and wildfire—that collectively serve to illustrate the ten key elements enumerated in the previous section.

4.1 Water

Most RISAs have a significant focus on water because of its deep connections to other societal and environmental needs, like agriculture, energy, aquatic ecosystems, wildfire, and human health. Stakeholders with significant interest in water have been at the forefront of adoption of new applications of climate science, owing in part to their extensive computational and technical capacity.

Early successes resulted from applying seasonal forecasts to water supply. As early as 1997 Seattle Public Utilities and several other stakeholders began paying attention to seasonal forecasts, and even applying them internally, in partnership with CIG (northwest RISA). CIG also issues annual ENSO-based seasonal hydrologic forecasts (Hamlet et al., 2002) that are now closely watched by public and private entities alike. Likewise, Pacific island water resource managers used ENSO forecasts to determine how to plan for water system conservation, with assistance from the Pacific RISA.

Drought cuts across sectors in ways that no other natural environmental hazard does, because water is fundamental to municipal water supplies, public health, fire, agriculture and food production, ecosystems, energy production, and more (Wilhite and Buchanan-Smith, 2005). Thanks in part to unusually prevalent western and southeastern U.S. droughts since 1999, several RISAs have had the opportunity to engage in drought planning, monitoring, and post-drought analysis. CLIMAS (southwest RISA) worked with State agencies in Arizona to construct the Arizona Drought Preparedness Plan. In the Carolinas, RISA scientists developed a regional drought monitoring tool used to determine and monitor low-flow triggers for Federal Energy Regulatory Commission dam relicensing processes (Carbone et al., 2007). RISA scientists and regional and municipal water managers in the West led to infusion of NOAA paleoclimatology program analyses and data into water resources planning and the adoption of new modeling methods for evaluating the sensitivity of water supply to drought (Woodhouse and Lukas, 2006). CIG researchers also found strikingly different institutional responses in Oregon and Idaho to the 2001 drought. RISAs worked over several years with Western Governors' Association to develop the framework for the National Integrated Drought Information System, and the newest RISA (SCIPP, the south-central RISA) has a major focus on drought.

Vigorous efforts by RISA scientists to educate stakeholders about the emerging science of climate change have convinced many public agencies and businesses that climate change may pose significant challenges to future water supply. Indeed, work by RISA scientists and others show that many of the expected changes are already detectable (e.g., Barnett et al., 2008). Using fine regional scale observations, global climate model simulations, down-scaling technique, and a set of hydrologic models, RISA scientists have projected future streamflows on scales from the small watersheds supplying urban needs, to the large basins of the Colorado and Columbia Rivers. Such projections are now routinely being used in long-range planning and assessments by municipal and State governments in partnership with RISAs as in California, Colorado, and Washington. A multi-RISA project, "Reconciling Projections of Future Colorado River Stream Flow," compares different modeling approaches to see how well these methods can reproduce recent flows, as part of a larger cross-RISA effort to help western U.S stakeholders deal with drought and climate change.

For water resources planning, western RISAs have worked for a number of years with the U.S. Bureau of Reclamation and related agencies to understand uses of climate information and respond to these needs. Early efforts included studies of the Salt River Project in Arizona, as well as the Aspinall Unit in Colorado (e.g., Ray, 2004). When the Bureau of Reclamation began considering climate change, their personnel were already well acquainted with RISA scientists and turned to them for information. As a result of a process including WWA (intermountain west RISA), CAP (California RISA), and CIG, long-term climate variability, risk of extended drought, and climate change were included in the National Environmental Policy Act process for contending with shortage on the Colorado River.

4.2 Agriculture

The SECC (southeast RISA) has demonstrated a successful regional approach for climate services for the agricultural and water sectors with most of the Essential Elements of Climate Services presented in this document. With multi-agency funding and input from farmers, Extension Agents, and foresters, the SECC developed a climate risk management decision support system (*http://AgroClimate.org*). This system was transitioned to the Cooperative Extension Services, which now operates this system and provides education programs and climate in formation to all counties in four SE states. The success of this research-to-operational program has also

been demonstrated through financial support provided by the USDA and by other states adapting AgroClimate for their agricultural stakeholders. For example the most recent support from USDA translated AgroClimate into Spanish to serve farmers who would otherwise not be able to make use of this information. Now that this system is in use, the RISA is developing similar climate information and decision support systems for water resources managers and coastal resource users. The SECC is focusing much of its research to develop information to address needs expressed by a wide range of stakeholders, working with Extension to reach county and city managers, water managers, coastal resource managers, land developers, public utilities, and other sectors. Many of the new demands for local and regional climate services are for information options for responding to climate change.

Using integrated climate and social science research, CLIMAS is investigating the prospects for improved use of climate information by ranchers in the Southwest. CIG is using a crop model to evaluate impacts of climate change on key crops in Washington State.

4.3 Wildfire

Wildland fires cost the United States over $1 billion annually and their severity is determined by several factors including climate, vegetation and human behavior, on timescales from weeks to decades. Successful climate services supporting wildland fire management and prediction require multi-agency coordination and multi-disciplinary perspectives. In anticipation of sustained dry conditions, CLIMAS, CAP, and SECC convened a ground-breaking 2000 workshop to bring together climate scientists and fire management stakeholders (Morehouse, 2000). After first hearing that the fire management community did not see an obvious need for climate information, a spirited discussion stimulated interest in using historical ENSO information and climate forecasts in pre-season fire prediction. Scientific knowledge was too new for operational implementation at first, so the RISA program facilitated sustained science-management exchanges, which led to identification of early adopters, potential agency partners, and better understanding of the insertion points for climate information in fire management decision-making (Corringham et al., 2008).

In 2003, CLIMAS, the National Interagency Coordination Center's Predictive Services Group, and the Program for Climate, Ecosystem, and Fire Applications (a contributor to the CAP RISA) began developing pre-season fire potential climate outlooks for the conterminous United States and Alaska through a decision support process called the National Seasonal Assessment Workshops (NSAW) (Garfin et al., 2003). Over the years this process has improved understanding of climate forecasts and forecast evaluation, and facilitated connections between NOAA science and operational entities and the fire community. RISA involvement and partnership has catalyzed change in (a) operational use of climate forecasts by this stakeholder community, and (b) climate-fire integrated research and prediction (Brown and Kolden, 2007).

The pre-season outlooks are used by the National Multi-Agency Coordinating Group in firefighting resource allocation decisions, including pre-positioning of resources, personnel planning, prescribed and wildland fire use decision-making, and fire mitigation (park closures and fire bans). Outlooks are now routinely used to brief the Secretary of Agriculture and have been successfully transferred to operations.

CAP, CIG, CLIMAS, and ACCAP (Alaska's RISA) have contributed substantially to climate-fire research, particularly on the subject of climate change. CIG research demonstrated that in most western states, a substantial portion of the inter-annual variability and long-term trends in area burned can be explained by considering summer climate (McKenzie et al., 2004). Collaborative CAP and CLIMAS research elaborated the mechanisms, focusing on spring snowpack and on fire season length and other fire parameters (Westerling et al., 2006). CIG research further distinguished climate-fire relationships for different eco-regions (Littell et al., 2008). ACCAP researchers recently developed a fire forecasting tool for use by agencies in firefighting asset management. These results have been of great interest to forest ecosystem managers, insurance companies, timber companies, and others.

4.4 Reflection on key elements

In the examples just given, a central theme is the focus on user needs as the driving force, as well as on assessment and partnership as mechanisms to identify and fulfill need. In many cases the scientists took the lead in contacting stakeholders and educating them about emerging climate science, and piqued the institutional curiosity of the stakeholders. Two examples are the fire season outlooks and the use

of climate model projections by municipal utilities. Growing interaction provides both the climate scientists and the stakeholders with insights regarding new products, for example the fire season outlooks, that could be developed and used. Social-science research also proved essential in stakeholder needs assessment.

Another theme is the success of cross-institutional interagency interactions. The wildfire example was explicitly multi-agency, and it was a multi-agency institution that ultimately made climate an integral part of their operational efforts. The fire season outlooks include USFS; an array of NOAA entities, including CPC, ESRL, and NWS; IRI, Scripps ECPC, Regional Climate Centers, and the CLIMAS, CAP, WWA, ACCAP, and SECC RISAs.

Moreover, SECC has forged a successful partnership with USDA and with the State climatologists of its three constituent states, Florida, Georgia, and Alabama. CIG annual workshops on water resources outlooks likewise involve USDA, NRCS, the NOAA River Forecast Center, and a close partnership with Idaho Department of Water Resources. Operational forecasts of coho salmon returns were developed in a collaboration between CIG and NOAA fisheries scientists (Lawson et al., 2004), and because the collaboration included agency scientists the result was both usable and influential. These partnerships, and many others, provide RISA teams with the broad expertise—and best practices—needed to carry out their mission of meeting stakeholder needs.

Other partnerships extend internationally. The Pacific RISA emerged as a demand for climate research and policy from stakeholders established by the Pacific ENSO Applications Climate Center, which serves the U.S. client jurisdictions of American Samoa, Federated States of Micronesia, Guam, Hawaii, Northern Mariana Islands, Marshall Islands, and Palau. Partnerships extend across the Pacific to the Fiji Met Service, New Zealand's National Institute for Water and Atmospheric Research, Australia's Bureau of Meteorology, and Pacific regional environmental and disaster management organizations. These partnerships ensure value and consistency of climate information, and the network establishes the Pacific Climate Information System (PaCIS), a regional climate services example.

CLIMAS in the southwest and CIG in the Northwest also have partnerships in Mexico and Canada respectively. Climatic, hydrologic, and ecological issues cross the border and cannot be solved without recognizing that fact. CIG has partnered with Canadian organizations like the Columbia Basin Trust as it grapples with climate change, and helped train hydrologists at the University of Victoria's Pacific Climate Information Consortium. One of CLIMAS' regular stakeholder publications, the bilingual monthly *"Border Climate Summary/Resumen del Clima de la Frontera"* is co-produced with colleagues in Mexico. CAP, along with many other university, State, federal and NGO partners, is centrally involved in an ongoing biennial assessment of California's vulnerability and adaptive capacity to climate change. The California experience has demonstrated that, when defined goals are set, the State Government and research community is able to collaborate across disciplinary lines to produce useful analyses and syntheses—this effort that has produced scenarios-based climate evaluations in 2006 and in 2009 (Cayan et al., 2008; Franco et al., 2008; State of California, 2009).

Placing climate information in the stakeholders' interdisciplinary decision context is also critical. WWA is working with a number of municipal and other large-scale water providers, who are trying to understand the sensitivity of their systems and supply to climate change, but the looming issue is how population growth and land use change will affect the equation. Fluctuations in salmon populations in the Northwest are best understood as climatically driven within the context of along decline in salmon habitat extent and quality.

The examples given above are but a small subset of the climate services developed by the RISAs that would not have been possible without the inherently regional understanding, approach and presence of the university-based RISAs. Education, training and literacy-building was also integral, as was the production of a steady flow of graduate students and post doctoral researchers trained to do stakeholder-driven, interdisciplinary climate research—many now work in other regions, have helped spawn new RISAs, or work in government agencies. Clearly, both climate variability and change are needed foci, and for example, many stakeholders originally focused on climate variability and skeptical of climate change, are now actively working on climate-change adaptation strategies.

Lastly, much of the regional RISA success in supporting stakeholders would have been impossible with out federal agency partners, particularly in NOAA, but in other agencies as well. The RISA program has successfully transferred a number of programs to their federal operational partners, and the national science enterprise (e.g., the Climate Change Science Program and the U.S. Global Change Research Program) is integral to RISA success at the regional level.

5. Implementation Advice

Implementing a vision for national climate services will require careful deliberation including all major federal and non-federal partners, and we can do no more here than offer some thoughts based on the RISA experience. Primary issues to be addressed include governance structure, funding, and defining roles for federal agencies and nonfederal partners in a way that recognizes their respective missions, strengths, and limitations.

Many RISAs were involved in the first U.S. National Assessment, a large climate-focused interagency effort whose strengths and weaknesses have been discussed elsewhere (Morgan et al., 2005). The National Assessment included five sectorally focused activities, 17 regionally focused activities, and one focused on native peoples and homelands. Among the lessons are (1) each regionally or sectorally focused activity had a lead federal agency as a partner and fonder, which ensured an uncluttered reporting structure on the team level; (2) perhaps the biggest strength was that regional teams almost all had strong participation by stakeholders; (3) sustained funding is required to sustain interactions with stakeholders; and (4) the Assessment needed "a budgeting mechanism which would allow greater freedom in allocating resources across various assessment activities" (Morgan et al., 2005).

We note several other considerations of the federal context for National Climate Services. Though still in its early stages, the National Integrated Drought Information System (NIDIS) provides a working example of a multi-agency partnership intended to connect climate science to decision-makers. Another federal context for the development of climate services is the re-examination of the *U.S. Global Change Research Act of 1990* and the Climate Change Science Program. The National Weather Service some years ago designated a "climate focal point" at each weather forecast office, someone to discuss seasonal forecasts. These must be augmented by experts in climate dynamics, global change, water resources, and so on, at other federal and non-federal institutions, to build a climate service.

Clearly the governance structure and funding must be designed so that participants particularly the regional decision-makers in society—are the primary drivers of climate services enterprise, and so that the whole is greater than the sum of its parts. This means ensuring that each federal agency has sufficient new funding, working authority, and intellectual motivation to engage in climate service activities that relate to its central mission, and to collaborate with other federal agencies and other partners. It also means that mechanisms be established so that regional stakeholders have a real say in setting funding priorities for all aspects of the climate services enterprise.

The preeminence of NOAA in climate observations, research, and prediction, and the differences between the role of a climate service and the primary tasks of the other agencies, lend weight to the argument that NOAA should play a lead role overall, although certainly other agencies should appropriately play a lead role on specific topic areas. For example, USFS should clearly take the lead on forest management and planning in order to manage the massive land-cover transformations that are sure to be a part of world that is undergoing climate change.

Another RISA lesson is that longer-term funding mechanisms ensure that regional partners, for example at universities, can entrain and sustain the stakeholder partnerships that are needed for success. The current NOAA model works well, with extended period grants (i.e., five-year once a RISA is mature and proven) competed at five-year intervals for each region.

Some RISAs are working examples of multi-agency partnerships as well, with funding and participation by USGS, USFS, USDA and others. University-based scientists, agency scientists, and agency managers collaborate on researching and developing new climate knowledge with clear applications in mind, and host frequent workshops to extend the connections to other partners, as discussed in some of the examples above. Some RISA participants have joint university—agency appointments, formally bridging the two institutional environments and ensuring better communication of research results to others within the agency. In the province of Quebec, a RISA-like entity called Ouranos takes such partnership one step further: personnel from several universities, one federal agency, the provincial hydropower company, and several provincial ministries interact daily because they all work together in the Ouranos office. Another example of successful regional multi-agency partnerships involves the co-location of NOAA Sacramento Weather Forecast Office and California Nevada River Forecast Center with the California Department of Water Resources' Hydrology, Flood Operations Office, and the State Climatologist. Federal and State staff work side-by-side to produce daily river forecasts, issue flood bulletins, water supply forecasts, and to share and exchange data. The added benefit to users comes from the regional integration of various sources of observations, forecasts, and expertise to produce internally consistent information.

Governance of a climate service should probably include a cabinet-level council, led by the Secretary of Commerce, to ensure agency cooperation and coordination at the highest level. A second, working-level council involving all participating federal agencies and key non-federal partners would oversee the climate services efforts in greater detail. Participation by non-federal partners would be crucial, since much of the on-the-ground connection to decision-makers happens in the RISAs, the regional climate centers, State climatologists, and private sector experts.

Finally, we note that the Climate Working Group of NOAA's Science Advisory Board recommended considering four structural options for a national climate service:

1. Create a national climate service federation that would determine how to deliver climate services to the Nation;
2. Create a non-profit corporation with federal sponsorship;
3. Create a national climate service with NOAA as the lead agency with specifically defined partners; and
4. Expand and improve weather services into weather and climate services within NOAA.

An assessment of these four options is underway by NOAA and its partners.

6. Conclusions and outlook

The RISA teams have successfully built knowledge-action networks to provide useful climate information, connecting the climate research enterprise with real-life situations where the outputs of that enterprise can materially improve the lives of Americans. These successes have required very modest investment and have had large payback to the Nation.

The RISA teams also see huge gaps that a mature and well-designed National Climate Service could fill. One obvious gap is purely geographic: only about half the land area of the Nation is actually served by RISAs. Another gap is the fact that when a product or decision support tool is developed through RISA research, there is generally no obvious mechanism to provide a transition to an operational environment, as was done with the fire season outlooks.

Three emerging issues need the kind of effort that only an NCS could provide. In all three of these cases, basic research can be connected to stakeholder needs through RISA efforts and/or a national-scale sectoral research program—that is, the stakeholder demand already exists. The first is the need for vigorous research on *decadal-scale predictions* with a goal of providing outlooks with skill demonstrated from hindcasts and with uncertainties properly characterized; such outlooks would help fill an oft-stated need of stakeholders. These predictions would be useful for a variety of decisions, but are not yet produced either by the seasonal forecasting entities like NCEP nor by the climate change simulations of IPCC.

The second emerging issue concerns *sea level rise,* which is already a great concern for coastal communities from Alaska to the Pacific Islands to the Carolinas. Stakeholders want probabilistic guidance about sea level rise on a very fine spatial scale, overlaid on planned or existing infrastructure, beach slopes, inland estuaries, wetlands, and river deltas. Meeting these demands will require a concerted effort among ice sheet researchers, coastal oceanographers, wetlands scientists, and social scientists, to name a few. As a stopgap, a few RISAs have attempted to provide such guidance (e.g., Cayan et al., 2007, Mote et al., 2008) but without the full complement of needed expertise.

The third is a crosscutting issue, the issue of *climate adaptation.* Vigorous research in social sciences including economics, policy, and law, are needed in conjunction with climate and natural science research to provide tools and processes for building adaptive capacity, especially at the local to regional level. A significant step in this direction was the creation of a *Guidebook for local, regional, and State governments* (Snover et al., 2007), a joint effort of CIG and staff from King County (which includes Seattle), Washington, and all the RISAs are already in jeopardy of being overwhelmed by stakeholder demand for help in adapting to climate change (in addition to climate variability). Adaptation science and application must also be an integral part of the decision-making currently underway on alternative energy deployment and climate change mitigation—for example, regional adaption needs for land and water resources should be factored in as early as possible, and before costly mistakes are made.

The RISA experience also highlights the central role that universities must play in NCS. Universities have a tradition of trusted regional stakeholder partnerships, as well as the interdisciplinary expertise—including social science, ecosystem science, law, and economics—required to meet stakeholder climate-related needs.

Universities have a proven ability to build and sustain interagency partnerships. Universities excel in most forms of education and training. Universities also have proven innovation, entrepreneurship, technology transfer and capability for partnership with the private sector.

RISAs have become a resource in their respective regions for dealing with climate variability and change in practical ways. When drought or climate change or sea level rise became a central issue for Bureau of Reclamation, U.S. Fish and Wildlife Service, U.S. Forest Service, and State governments in Alaska, Washington, Idaho, California, Florida, and elsewhere, these stakeholders turned to RISAs for technical, intellectual, and policy assistance.

A well-funded, carefully designed, and properly governed NCS will meet the rapidly growing needs for applied climate information, drawing together partners from federal agencies, academic partners, private sector, State climatologists, and other experts. The experiences in the RISA program offer many useful lessons in the design of an NCS.

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This document was prepared by Cheryl Anderson (Pacific), Dan Cayan (CAP), Mike Dettinger (CAP), Kirstin Dow (CISA), Holly Hartmann (CLIMAS), Jim Jones (SECC), Ed Miles (CIG), Philip Mote (CIG), Jonathan Overpeck (CLIMAS), Mark Shafer (SCIPP), Brad Udall (WWA), and Dan White (ACCAP). For contact information, please go to the RISA web site at: *http://www.climate.noaa.gov/cpo_pa/risa/*

BIOGRAPHY FOR PHILIP W. MOTE

Prof. Mote serves as Director of the Oregon Climate Change Research Institute and Oregon Climate Services at Oregon State University, and is a Full Professor in the College of Oceanic and Atmospheric Sciences. Until July 2009 he also works at University of Washington (UW) as a research scientist with the Climate Impacts Group, where since 1998 he has built the group's public profile through hundreds of public speaking events, over a thousand media interviews, deep engagement with the region's stakeholders, and ground-breaking research in the impacts of climate change on the West's mountain snow and on wildfire. He has published over 70 scientific articles and edited a book on climate modeling. He serves as State climatologist for Washington and, as Director of Oregon Climate Services, serves in a similar role there. He was a lead author of the IPCC Fourth Assessment Report; the IPCC was awarded the Nobel Peace Prize in 2007. In 2008 he received the UW Distinguished Staff Award and was named one of the region's 25 most influential people by *Seattle Magazine.* He earned a Ph.D. in atmospheric sciences from UW and a BA in physics from Harvard.

Chair BAIRD. Thank you. Mr. Hirn.

STATEMENT OF MR. RICHARD J. HIRN, GENERAL COUNSEL AND LEGISLATIVE DIRECTOR, NATIONAL WEATHER SERVICE EMPLOYEES ORGANIZATION

Mr. HIRN. Chairman Baird, Ranking Member Inglis, and Members of the Subcommittee, thank you for offering the National Weather Service Employees Organization the opportunity to

present its views on options for developing a National Climate Service.

It is our view that the creation of a National Climate Service as a separate line office within NOAA is unnecessary, because it would duplicate the historic and current mission, program, and services of the National Weather Service, and will inevitably result in a reduction of resources for the Weather Service.

Today, nearly 1,000 employees of the Weather Service are performing climate service work as a key element of their jobs. The NWS already operates the surface and upper air observing systems that are the basis of the Nation's climate record. It conducts applied climate prediction research, and issues an extensive array of climate forecasts and outlooks. Moreover, the entire Weather Service has integrated climate into its current weather forecast and warning activities. Therefore, the new National Climate Service should be created as an entity within the National Weather Service, or the National Weather Service should be re-chartered as the National Weather and Climate Service, which in fact, is a better descriptor of its current mission.

Much of what a National Climate Service would do is already being done by the Weather Service's Climate Prediction Center in Camp Springs, Maryland. The CPC performs global climate modeling, engages in applied climate research, issues predictions of climate variability, and assessments of the origins of major climatic anomalies.

Among its many climate products are the Atlantic and Eastern Pacific Hurricane Outlooks, the Seasonal Drought Outlooks disseminated by the National Integrated Drought Information System, and El Niño and La Niña Climate Forecast. The CPC even provides climate forecasts that assist the USAID with famine relief in Africa, Southeast Asia, South and Latin America, and Afghanistan.

Climate services are also fully integrated within the National Weather Service field organization and forecasting offices across the country, from acquiring national climatic data to producing and disseminating climate predictions. There is a Climate Service Program at each Weather Service regional office. Each of the Weather Service's 122 forecast offices issues a variety of climate products several times a day, and manages the government's Climate Monitoring Network. The data provided by this network is used for the management of water resources, prediction of crop yields, and the study of climate variability.

A number of the findings and recommendations contained in the Science Advisory Board's recent report on options for a climate service lead to the conclusion that a National Climate Service should be embedded within the Weather Service. First amongst the SAB's recommendations was that: "An internal reorganization of NOAA that enables greater connectivity of weather and climate functions is a necessary step for success." Therefore, rather than standing up the National Climate Service as a separate new agency, NOAA should consolidate the disparate climate programs in other NOAA line offices with the climate service programs already provided by the National Weather Service. The SAB also concluded that: "From every practical standpoint, this option is the simplest

to implement." In other words, we already have a shovel-ready National Climate Service.

The alternative, which has been proposed by NOAA, is to sever weather from climate by some arbitrary temporal distinction between the two, or worse yet, duplicating services and programs already delivered by the Weather Service. Not only would this be a waste of resources, but there would be no authoritative voice in climate matters.

As the SAB noted in its findings: "The greatest strength of a combined Weather and Climate Service are an ability to speak with an authoritative voice, build quickly from existing components of a Climate Service, and an ability to ensure one stop shopping if weather and climate functions are integrated."

Finally, it is not possible to transfer the ongoing climate services performed by the NWS into another line agency, since they are so functionally integrated with the day to day operations of the Weather Service, and are widely dispersed among over 150 NWS offices. Prediction of the climate cannot be severed from prediction of the weather.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Hirn follows:]

PREPARED STATEMENT OF RICHARD J. HIRN

Chairman Baird, Ranking Member Inglis, and Members of the Subcommittee. Thank you for offering the National Weather Service Employees Organization the opportunity to present its views on the options for developing a National Climate Service. As you may be aware, NWSEO represents not only the forecasters and technicians at the National Weather Service, but employees throughout NOAA, including employees at OAR and NESDIS.

It is our view, and that of many in National Weather Service management, that the creation of a National Climate Service as a separate line office within NOAA would be an unnecessary expense because it would duplicate the historic and current mission, programs and services of the National Weather Service, and will inevitably result in a reduction of resources for the NWS.

Today, nearly 1,000 employees of the National Weather Service are performing Climate Service work as a key element of their jobs. The NWS already operates surface and upper air observing systems, monitors climate variability in real time over a broad range of time scales, conducts applied climate prediction research, and issues an extensive array of climate products and information, including climate forecasts and outlooks. Moreover, the entire National Weather Service workforce has climate integrated into its current weather forecast and warnings activities. NWS Director Jack Hayes has said that the NWS is "at the forefront of climate service delivery to this nation" and "is critical to . . . advancing NOAA's mission goal for a National Climate Service."

Therefore, the new National Climate Service should be created as an entity within the National Weather Service, or the NWS should be re-chartered as the "National Weather and Climate Service," which is in fact a better descriptor of its current mission.

The NWS is already the Nation's "National Climate Service"

According to *National Weather Service Policy Directive 10–10,* issued by NWS Director Jack Hayes on January 29, 2008:

> *Provision of climate services, in particular the monitoring of variations in climate and climate forecasting, is essential to mitigate the loss of life and property and to enhance the national economy. The NWS is the federal agency charged with delivering these services to the U.S., its territories, and, as appropriate, its interests abroad.*
>
> *http://www.weather.gov/directives/010/010.htm*

Much of what a National Climate Service would do is already being done by the **Climate Prediction Center (CPC)** in Camp Springs, Maryland which is part of

the National Weather Service. The CPC performs global climate modeling, issues predictions of climate variability, and assessments of the origins of major climate anomalies. Among its many climate products are the Atlantic and Eastern Pacific hurricane outlooks; the seasonal drought outlooks disseminated by the National Integrated Drought Information System; and El Niño/La Niña climate forecasts. In January alone, over 30 million visitors obtained climate forecasts from the CPC's website.

The International Weather and Climate Monitoring Project at the CPC provides climate forecasts that assist the USAID with famine relief in Africa, Southeast Asia, South and Latin American and Afghanistan. The CPC's Africa Desk works with the governments of over 30 countries in sub-Sahara Africa by providing climate monitoring and predictions. The CPC trains twelve meteorologists a year from Africa in climatology during a four month residency program.

The CPC provides climate forecasts out to thirteen months, and with modest additional resources, it could produce climate outlooks covering decadal time frames. The CPC engages in applied climate research; makes assessments of climate variability and climate anomalies; and provides services to other federal agencies such as the Departments of Agriculture and Energy, FEMA and the EPA, as well as foreign governments, academia, and private sector agricultural, energy, construction, insurance, and leisure industries.

Climate services are also fully integrated within the NWS' field organization and forecasting offices across the Nation, from acquiring national climatic data to producing and disseminating climate predictions.

The *NWS Organic Act of 1890* charges the NWS with the responsibility for "the taking of such meteorological observations as may be necessary to establish and record the climatic conditions of the United States." The Nation's official climate record is based largely on observations from the NWS' Cooperative Observer Program. The COOP program consists of 11,400 observation stations that report daily minimum and maximum temperatures, precipitation, snowfall, snow depth or hydrological data. This network, along with about 1,000 Automated Surface Observation Stations, forms the Federal Government's weather and climate monitoring network. The data provided by this network is used for real time forecasting, management of water resources, prediction of crop yields, and the study of climate variability.

There is a **"Climate Services Program" at each NWS Regional Office.** For example, the NWS Alaska Region's Climate Services Program centers around a number of indicators of climate change in Alaska and the Arctic: sea ice melt and retreat; glacier melt; warming temperatures; thawing permafrost with loss of infrastructure; precipitation pattern shifts, coastal erosion and flooding; ecosystem shifts; and potential health epidemics. The Alaska Region's Climate Services Program is addressing observations, monitoring, and assessments with its partners and collaborators to provide new climate products for a changing climate and is making this information available to local and regional decision-makers and the general public. As part of this effort, the NWS Alaska Region has partnered with the Alaska Center for Climate Assessment and Policy to provide monthly Alaska weather and climate highlights on a web site.

The NWS Central Region's Climate Services Program covers agriculture, bio-energy, and drought impacts and planning. It disseminates information, including climate change, weather/climate data, water and drought planning information, through many entities, including extension services, State climate offices, various academic institutions, and other decision-makers.

Each of the 122 Weather Forecast Offices routinely issues climate products, including the "Supplementary Climate Data Report" every six hours, "Daily Climate Report" two or three times a day for several locations, a "Monthly Climatological Report" and National Drought Information Statements.

The Science Advisory Board's Report noted that the "NWS field offices are highly visible points-of-contact for a wide range of [climate] information requests." The National Weather Service has published a comprehensive plan or "Operations Document" for "Regional and Local Climate Service Delivery" (November 2007) which charges the staff at the Forecast Offices and other local NWS offices with the responsibility for outreach and education in each office's area of responsibility on climate products, data and information. *http://www.weather.gov/om/csd/graphics/content/about/Ops2.pdf* **One of the forecasters at each WFO serves as a "Climate Services Focal Point," but** other Forecast Office staff members respond to public climate information inquiries as well. Forecast Offices conduct workshops targeted to local audiences (media, agriculture sector, energy and weather risk management industries) to educate customers on the potential uses and availability of climate resources and to gather feedback on climate products and services. Local

Forecast Offices are also charged with establishing and maintaining partnerships with other members of the climate community in the local area, including the Regional Integrated Science and Assessments (RISAs), universities, State Climate Offices and the Regional Climate Centers. Forecast Office staff are also charged with conducting climate analyses at scales important to local customers. Attached to this testimony is a sample page from the Tampa Forecast Office's web site which illustrates some of the kinds of climatic information disseminated by local Forecast Offices.

In addition, the "Observational Program Leader" (OPL) and the Hydrometeorological Technicians at each Forecast Office manage the Cooperative Observer Program—a prime element in recording the Nation's climate. The OPLs are charged with maintaining the climate observational equipment while also recruiting and training the thousands of observers who comprise the "citizen corps" of NWS climate observers. Each office maintains the Automated Surface Observation Systems in the WFO's area of responsibility. Twice a day, specially trained and certified staff at 70 Forecast Offices launch instrumented weather balloon packages to collect current atmospheric data critical to atmospheric predictive modeling and to establish the earth's climate profile up through the stratosphere.

The **Anchorage Weather Forecast Office Sea Ice Desk** performs Sea Ice analysis, Sea Surface temperature analysis, and Sea Ice Forecasts for the North Pacific/Bering Sea and portions of the Arctic Ocean. The changes in Sea Ice coverage shown by these analyses are an important indicator of climate change.

The **18 smaller Weather Service Offices in Alaska and Pacific Regions** also launch and collect data from instrumented weather balloons and respond to public climate information inquiries. Some also daily issue climate products such as the Supplementary Climate Data Report and Daily Climate Report. Four WSOs in Alaska take sea-ice and sea surface temperature observations. The duration of open waters is very important to determining Arctic sea ice climate change.

The **13 NWS River Forecast Centers** collect and archive hydrological, snowfall, snowpack depth and rainfall data. Some offices have collected over 100 years of historical data. The River Forecast Centers are also responsible for Flood Climatology and Flood Frequency Program data collection and archiving vital for FEMA and flood insurance. The Alaska RFC collects and archives river and lake freeze-up dates and ice thickness measurements, which are important indicators of climate change in the region where climate change is now occurring the fastest.

The **Climate Services Division** at the NWS headquarters acts as the portal for NOAA information on climate change and variability, oversees the NWS's operational climate services programs, identifies user requirements for climate data and products, and develops training on climate services for NWS field staff.

Other federal agencies, such as the Department of Agriculture, use the aforementioned NWS generated climate data, products and services to administer and oversee nearly $1 billion in pasture, rangeland, and forage insurance products. State and Federal Wildland Fire agencies use NWS climate forecasts for wildland fire planning purposes.

NWSEO agrees with many of the Recommendations and Findings of the NOAA Science Advisory Board

A number of the findings and recommendations contained in the NOAA Science Advisory Board's report, *"Options for Developing A National Climate Service"* (February 2009), lead to the conclusion that the National Climate Service must be embedded in the National Weather Service. In evaluating the question of whether the National Weather Service should serve as the platform for a National Climate Service, the NOAA Science Advisory Board concluded that, **"from every practical standpoint, this option is the simplest to implement."** Therefore, rather than standing-up the National Climate Service as a separate line office, NOAA should quickly consolidate the disparate climate programs in other NOAA line offices with the climate service programs already provided by the National Weather Service.

First among the SAB Report's recommendations is that an "internal reorganization of NOAA that enables greater connectivity of weather and climate functions is a necessary step for success." Also among the Report's findings is that "the current NOAA organization is not well-suited to the development of a unified climate services function. Greater connectivity between weather and climate functions . . . is required." The SAB "tiger team" that studied the National Weather Service recommended that three NOAA data centers (the National Climate Data Center, National Oceanographic Data Center and National Geophysical Data Center) be transferred from NESDIS to the NWS as part of a new "National Weather and Climate Service" to more fully integrate climate services in one agency. Consolidation of these data centers with the climate programs of the NWS would link the new

Weather and Climate Service to the Regional Climate Centers and State Climatologists because of their existing ties to the NCDC. As the SAB "Tiger Team" explained, "[t]his organization simplifies the seamless distribution of information ranging from past history through present conditions to weather forecasts and forecasts of inter-seasonal to inter-annual." As noted earlier, with additional resources, the Climate Prediction Center can extend it predictions and assessments to the decadal time frame.

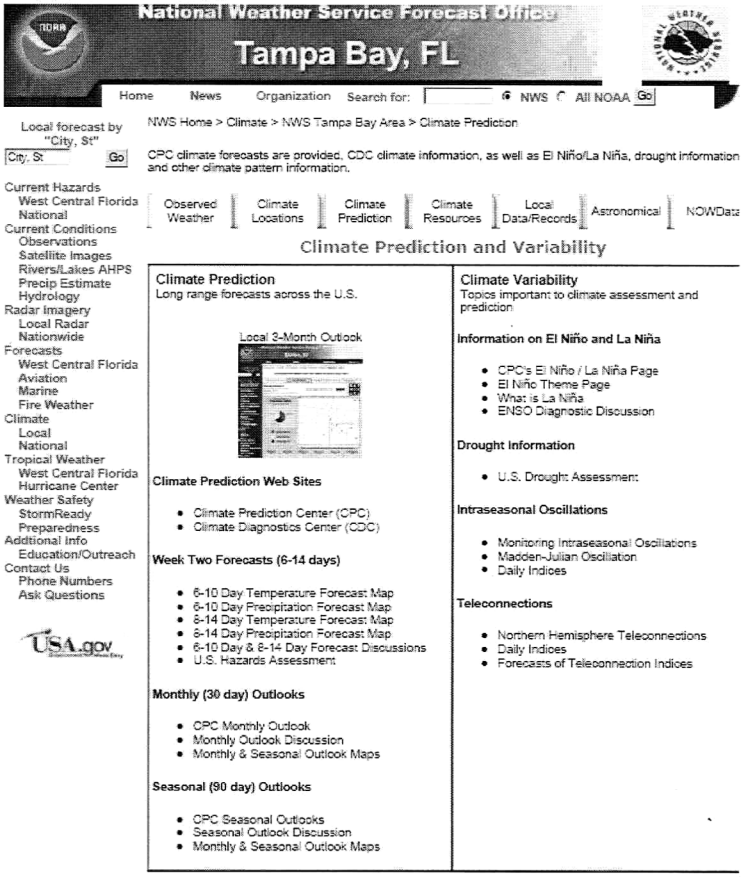
The SAB also concluded that "greater connectivity between . . . research, operations and users is required." Therefore, NWSEO suggests that the Climate Program Office in NOAA's Office of Oceanic and Atmospheric Research also be transferred to the NWS. The CPO is already co-located with NWS headquarters in Silver Spring, MD. At a minimum, consideration should also be given to transferring the Climate Observations Division of OAR's Climate Program Office to the new Weather and Climate Service. This Division has three operational observing programs—Ocean Climate Observation, Arctic Research Program and Atmospheric Climate Observations. This would link these real-time weather and climate observation programs with the observation programs now maintained by the NWS, as well as the new observation network (the "Climate Reference Network") being spun-up by the NCDC.

The alternative—which has been proposed by NOAA leadership—is to sever weather from climate by some arbitrary temporal distinction between the two; or, worse yet, to duplicate services and programs already delivered by the National Weather Service. Not only would this be a waste of resources, but there would be no authoritative voice on climate matters. As the SAB noted in its findings, "the greatest strength of a . . . combined weather and climate service are an ability to speak with an authoritative voice, build quickly from existing components of a climate service . . . and an ability to ensure 'one-stop shopping' if weather and climate functions are integrated."

Further, it is not possible to transfer the ongoing climate services performed by the National Weather Service to another line agency, since they are so functionally integrated with the day-to-day operations of the National Weather Service and are widely dispersed through among over 150 NWS offices. Moreover, prediction of the climate cannot be severed from prediction of the weather. Today's climate prediction will eventually become tomorrow's weather forecast; and come tomorrow, today's weather will be part of our climate history.

The SAB "Tiger Team" that studied the option of creating a new, not-for-profit National Climate Service noted that this option would create "potential competition with NWS offices" and would not be able to speak with an authoritative voice like the NWS. The Report failed to address the question of what would become of the climate services already performed by the National Weather Service—an issue which NOAA has also ignored in the development of its proposal to create the National Climate Service as a new line agency elsewhere in NOAA. We have, however, heard from NWS management that there are already proposals to transfer personnel and funding (specifically the personnel and funding that relate to the Historical Climatology Network) from the National Weather Service to NCDC as part of a plan to evolve NCDC into the new National Climate Service.

In short, the Nation already has a "shovel-ready" Climate Service. With some additional resources, the National Weather Service can augment the panoply of climate services that it already provides in order to meet the Nation's evolving needs for climate analysis and prediction. Thank you, Mr. Chairman, for allowing us to share our views with the Subcommittee on this important issue.



BIOGRAPHY FOR RICHARD J. HIRN

Richard J. Hirn is an attorney whose practice focuses on labor, civil rights, constitutional and administrative law and litigation. Mr. Hirn's cases have pioneered unique theories in constitutional law, employment discrimination, labor relations and other legal matters having public impact. For example, he litigated the first case of Hawaiian national origin discrimination, *Kahakua et al v. Friday.* This case was the subject of a special report on *All Things Considered,* broadcast on National Public Radio, and was the subject of an article in the centennial issue of *The Yale Law Journal,* "Voices of America: Anti-discrimination Law and the Jurisprudence for the Last Reconstruction." Mr. Hirn has been responsible for significantly expanding the collective bargaining rights of federal employees and their unions. Mr. Hirn represented the Fort Stewart Association of Educators before the Supreme Court, which ruled that Congress intended for federal agencies to bargain over wages unless salaries were specifically set by law. As a result of this unanimous Supreme Court decision, *Fort Stewart Schools v. FLRA,* 495 U.S. 641 (1990), wage negotiations became routine in a number of federal agencies.

Representative clients include national labor unions in both the private and public sectors, including the Nation's two largest teacher unions, federal employee unions, and those in the maritime and transportation industries. As part of his Washington,

D.C. based practice, he has represented numerous labor organizations before Congress and federal agencies.

Among the unions that Mr. Hirn represents is the National Weather Service Employees Organization. He has served as General Counsel of NWSEO since 1981 and has represented the organization in federal courts throughout the country, in collective bargaining and in labor arbitrations and has been quoted as its official spokesperson in *New York Times, Washington Post, USA Today* and other major daily newspapers; and interviewed on NBC's *Dateline* and on National Public Radio. Over the years, Mr. Hirn has visited scores of NWS and NOAA offices from San Juan, Puerto Rico to Lihue, Hawaii and Kodiak, Alaska. Since 2004, Mr. Hirn has also served as NWSEO's Legislative Director, and has testified before subcommittees of the House Science and Appropriations Committees on NWSEO's behalf.

Mr. Hirn was a member of the Obama Campaign's Labor, Employment and Worklife Policy Committee. He served as an elected Delegate to the 2004 Democratic National Convention as well as an Alternate Delegate to the 1972 Democratic National Convention.

Prior to entering private practice, Mr. Hirn was an attorney for the National Labor Relations Board. He was awarded a *Juris Doctor* degree by American University in 1979 and a B.A. in Political Science by Haverford College in 1976.

DISCUSSION

Chair BAIRD. Thank you, Mr. Hirn. Very interesting and thought provoking testimony. I should mention we have also been joined by Mr. Tonko. Thank you very much for joining us.

SUCCESSES OF CLIMATE FORECASTING

I will recognize myself for five minutes. Let me start by just getting a sense of what it is we have to offer here, in terms of accuracy and benefits. When someone comes and says okay, I need a climate forecast, and I thought Dr. Barron, your testimony was very eloquent, you know, and you listed the various reasons for doing it: human health, food security, disaster preparedness, energy, basically every aspect of our life is in some way going to be influenced by this, is influenced by it. The question is how we are able to prepare for that.

Give us some examples of where someone has, an entity has come and said give us a climate forecast, and that climate forecast has been given, and it has been beneficial economically, or in human health, et cetera. Have we got some success stories?

Dr. MOTE. Well, the RISAs have a number, sorry, the RISAs have a number of such success stories. One example was actually a partnership among several of the Western RISAs to cooperate with several federal agencies, to come up with a seasonal wildfire outlook. There are climatic aspects to wildfire risk, and this helps position resources, and this effort has been going on for a number of years. I have mentioned water resources. Energy is another one. There are linkages up and down the West Coast on energy supply. With hydropower, we know what the fuel availability is several months in advance, just based on the snow on the ground, but using a seasonal forecast, we can expect shifts in the probabilities of that fuel even several months in advance of that.

I could give you many other examples.

Chair BAIRD. That is a good start. Dr. Barron.

Dr. BARRON. I was going to add, for example, that major cities in the United States, notably New York City and Chicago, both have developed climate plans that are influencing their decisions

about infrastructure renewal, because that infrastructure is required to exist for many, many decades, as——

Chair BAIRD. If I built something that may one day be below sea level, and you need it to be above sea level, that is——

Dr. BARRON. Right, for which the water resource will change, as another example.

Chair BAIRD. Excellent points.

Dr. DEGAETANO. Mr. Chairman, can I——

Chair BAIRD. Please.

Dr. DEGAETANO.—on that? In New York, we are also looking at extreme rainfall, like Dr. Lubchenco mentioned earlier. We are not looking at just the big rainfall events, but kind of relating those to what we—from water or runoff in any of our cities. It is that the stakeholders actually base their decisions on, and providing them data based on the trends we have seen in the past years.

Chair BAIRD. So, you are giving them predictions, this is what we think is likely to happen the next 10, 20, 50 years.

Dr. DEGAETANO. Correct. The Administrator also alluded to that in her discussion, that the state-of-the-art, as far as climate modeling, is not enough to make those projections accurately out into the future. So, in that case, we do have to rely upon the trend that we have seen, to give some uncertainty in how to do it, if you are looking to build infrastructure that has a lifetime of 50 years, you don't want to go into that decision blindly, based on just some static record——

Chair BAIRD. Right.

Dr. DEGAETANO.—that is assumed to be stationary.

MORE ON STRUCTURING THE CLIMATE SERVICE

Chair BAIRD. Let us go into, then, this issue of, if we acknowledge that there can be benefits from this, let us talk a little bit about possible structures for this. We have heard Mr. Hirn suggest that maybe, they would, he would assert, his organization would assert that the Weather Service is basically already providing this. It needs to be possibly given that title and acknowledgment. Others have said there needs to be a separate or coordinating entity, that coordinates the various elements, perhaps Weather Service with the RISAs, et cetera.

What are the pros and cons of the different models, and I am going to leave that somewhat open, and Dr. Barron, I thought you were suggesting, you acknowledged a high level, possibly, I don't know if you said OSTP, but it sort of came to my mind, and Dr. Lubchenco had mentioned it. But then, it sounded like you talked about a nonprofit third entity, and let us talk about the pros and cons of that.

Dr. Barron, talk about that first, and then, if somebody wants to respond to Mr. Hirn's suggestion, pros and cons of that, and vice versa.

Dr. BARRON. Okay. So, I really think that we need many facets. No, one of the things that came out of the option report is none of those options were perfect. So, for instance, you may be able to stand up something quickly in NOAA, but how does NOAA partner with all of those other federal agencies? That requires something

that is quite different, in order to ensure that everybody is participating.

We have seen a lot of examples where we have created something like a National Carbon Program, but then, if one agency, because of other competing missions, doesn't involve themselves in it, it starts to fall apart, and it is no longer even close to what it is that you had set up. So, it cannot just be adding climate to weather. I think that is a rather different topic. So, that is one element of it there, to have that integration at a federal level, and I think, as high up in the structure as possible, and OSTP certainly makes sense.

But I think there is this other sense that we have a lot of users that cross all these boundaries that we are talking about. So, should every city have to redo the research themselves? Or if you are sitting there looking at oil rigs offshore, in many, many different states, can they all sit there at the table and work together, and generate the research that works on that? Or if you are looking at hurricane forecasting, do you have that capability? You wouldn't want to regionalize that.

And so, I think there was a sense among the options committee that an entity, a nonprofit, a facility, a center that promoted this, in terms of research and connecting to users was something that is important. There are many users out there that have a sense of what they want. And if you throw the data over the transom, they will go grab it. There are many, many other users who haven't realized the potential here yet. They are beginning to think about something. It is in three or four different places. They need some capability to integrate that. So, my feeling is this isn't a single story here that we have to facilitate.

Chair BAIRD. So, we are not necessarily one, the style that we are asking for, what is the one climate prediction, but what is the source one goes to to gather the multitude of perspective?

Dr. BARRON. And where do you go for help.

Chair BAIRD. Yeah. Mr. Hirn.

Mr. HIRN. Well, I have some concerns about this nonprofit federation that is outside the government. I question, of how much oversight that this committee and other Congressional committees would be able to give to that. I fear that that is just going to become a source of earmarking or maybe a source of pet projects, as time goes by, and would rather see it being done by a federal agency that is responsive to the public and the Congress.

I note that in Dr. Lubchenco's written testimony, and certain public statements she has made, she has talked about making it, using the National Weather Service as a model of private and public partnership for this National Climate Service. NOAA has not yet answered to anyone, and nor to the employees of the Weather Service, why would you use the National Weather Service as a model for this, rather than just continue to use the Weather Service for actually carrying it out, much as they do today?

Chair BAIRD. I recognize Mr. Inglis for five minutes.

How Existing Climate Offices Coordinate

Mr. INGLIS. Thank you, Mr. Chairman. I am still wondering about the, whether we are creating an overlap here, and whether, how to make this most efficient.

And as I understand it, I really am sort of unclear, so maybe you can help me understand the difference between what the work of the RISAs and the Regional Climate Centers, and the State climate offices. They work together, but they don't provide the same services. So, I wonder, are all three needed, or how much duplication is there between those three, the RISAs, the Regional Climate Centers, and the State climate offices?

Dr. DEGAETANO. Can I respond, Mr. Inglis? I was actually going to respond the same way to the previous question. What are the problems with having a large federal entity, be it a nonprofit or the Weather Service, kind of a place to go, is that the other side of climate services is the other way around. It has to be active. What we have seen in any number of years, in a lot of cases, like Dr. Barron said, you can't just throw the data over the transom and have people come to them. But you actually have to actively go out and seek out these people and talk to them. A good example is, I work with West Nile virus. You know, it was us going out and speaking to the people from New York City who control the mosquito population, public health officials, where we got the understanding of what were the climate issues in this problem.

It is very hard to do that from one place, be it regional, be it national. When you get down to the State level, or even the local-er levels than that, that is where those trust-based relationships are. You can think of the Service as almost like a funnel, where that information comes up, those ideas are generated, but when the Service becomes operational, when data go out, when models are developed, you have to make sure that these are all being based on the same data, the same models, the same ideas. That is where the regional comes into play.

You can think of it almost as the airline system, where perhaps the regional area is the hubs, and the State climatologists are the individual airports, and maybe the National Weather Service or some federal entity is the overarching company. The climate services work very much in the same way.

Dr. MOTE. If I could respond as well. The Western RISAs all have very good relationships with the Western Regional Climate Center, and I think we have sort of worked out a division of labor, that there is very little overlap.

Mr. INGLIS. And what is that division of labor? How does that work?

Dr. MOTE. I would say, and Dr. DeGaetano can correct me if I am wrong, but I would say that the Regional Climate Centers are best at understanding the climate data, the observations for the region. They typically do not, at least the Western Regional Climate Center doesn't do a lot of work, say, with global climate model output scenarios of future climate. The same is true of the Weather Service. Their climate focal points are not trained in dealing with some of these longer timescale issues.

The RISAs, based at universities, are focused on innovation, publishing research papers, coming up with new ideas, not so much operational. So, we have developed things that we have handed off to, for example, the River Forecast Centers within the Weather Service, or the Water and Climate Center, within the U.S. Department of Agriculture's Natural Resources Conservation Service.

Now, the State climatologists are best at having those relationships with individual entities within their states, and your State Climatologist, Hope Mizzell, is an excellent State Climatologist. She has developed a lot of great products for the State of South Carolina. Those are things that are supported by the Southeast Regional Climate Center, and informed by what is needed locally. So, the State climatologists are really listening locally.

A lot of this is not about, as Dr. Barron said, we don't just generate climate knowledge and throw it over the transom. We are actively listening to what people need, and responding.

Mr. INGLIS. Anybody else want—Dr. Barron.

Dr. BARRON. Well, I just want to point out that despite all these different components, it is still not good enough, and one of the reasons why it is not good enough is because these teams are small enough that they have to focus on particular areas. And therefore, they can't address the broad range of users. And it is very hard to cross from place to place.

So, what I see, as one of the really good examples is, in the '50s, we discovered that with computers, we could predict the weather, and we are getting pretty good at it, to the point where we close schools and do things in advance of a particular storm. If you take the human health community, they almost always react to the number of cases that came in the door. It is very rarely a forecaster prediction. Yet, so many different parts of human health are now tied to environmental conditions. But if you can predict environmental conditions, you can begin to predict adverse human health outcomes, and save an enormous amount of money.

Do I put that in a state? Do I put that in a region? It requires something that is quite different from that particular component, if we are all of the sudden going to realize the fact that out 15 years, we will be doing human health forecasts just like we do pollen alerts and air quality and weather forecasts.

But we don't have anything in place that allows those communities of users to intersect with this environmental prediction, climate modeling, weather forecasting groups, just as an example.

Mr. INGLIS. Thank you, Mr. Chairman.

Chair BAIRD. Thank you. Ms. Woolsey.

Ms. WOOLSEY. Thank you, Mr. Chairman.

Chair BAIRD. I should mention we have been joined by Ms. Edwards as well. Thank you for joining.

Ms. WOOLSEY. Thank you, Mr. Chairman. I would like to leave some time for the rest of the panel to respond to the Chairman's question, but before I do that, I would like to make a comment.

INTERNATIONAL COOPERATION AND DISSEMINATING REAL TIME CLIMATE INFORMATION

Wouldn't it be something if climate change became news like weather is now, because we actually, with the National Weather

Service, kind of conceive what is coming, and why it happened, and when it is going to happen? I think it would be very good, because then, the people of this country would see it as news, and not just as something that happened to them, that they have no control over.

And I just think this is all getting, leading us in the right direction, and I know that Chairman Baird wanted, you know, more, I thought that some of you wanted to answer, respond to Chairman Baird's question, his open question about why we need to do this, and what is a better way.

And as you are answering it, if you could, for me, talk about if there is opportunity for international cooperation in our get along here. So, I am doing part of your job for you. I am yielding to finish your question.

Chair BAIRD. I appreciate that, actually. I would have appreciated more time, but in deference to my colleagues, I gave back some, but thank you, Ms. Woolsey.

Mr. HIRN. Ms. Woolsey, I recently had a visit to the Climate Prediction Center in Camp Springs, I believe in Congresswoman Edwards' district. I visited what they call the Africa Desk there, which I was extraordinarily impressed. They do climate forecasting for Africa and other Third World, areas of the Third World, helping them with their drought predictions. But what I thought was most remarkable was I met a number of meteorologists from Malawi and elsewhere in Africa. The Weather Service brings 12 meteorologists a year from Africa for a four month residency at the Climate Prediction Center, and teaches them, trains them in climatology, to go back and work on drought prediction, things like that.

Ms. WOOLSEY. Well, that is very interesting, and that is, and let us get up to the doctors here, who didn't get to answer the Chairman, and maybe we will have time to talk some more about those people, the Africans that came.

Dr. DEGAETANO. I think there is tremendous opportunity for that, and the thing that we need to look at is exactly getting down to the regional scale, not looking at these broad global problems, but actually bringing data in, and projections, or even looking at data down to the regional levels, and starting to interact with stakeholders.

It may not be that we can make a prediction or a forecast on what the climate will be like in 2100, but to bring people along to see the types of things that they have to start concerning about. To make them more resilient to the types of climate variations we see today will only make it stronger in the future, when the modeling and capabilities are able to come around to make those projections at regional levels.

Ms. WOOLSEY. Dr. Barron.

Dr. BARRON. You know, I think the ground is so fertile, to make, to do so many things that are beneficial, or to at least have reasoned answers for particular actions. And you can look at one example after another. We are watching the Rocky Mountains being ravaged by the pine bark beetle, the first time that I know of, you know, leave only a footprint, take only a picture, we have used pesticides, insecticides in Rocky Mountain National Park, as an example.

So, now, when we watch these trees go away, do you live it? Do you plant the same tree again? Do you plant a different species, a more resistant species? This is a decision we are going to have to make one way or another. It would be nice to be able to integrate climate in there.

If you look at hurricane forecasting, everybody is talking about our hurricanes becoming more intense, or not intense. Climate models actually don't simulate hurricanes. They don't simulate hurricanes, because we don't have the power to get the climate models down to a resolution to simulate them. It is so important for so many coastal states. If we can embed weather forecast models in climate models, as part of a regional emphasis on climate, something we are not doing today, we will actually be at the point where we are simulating hurricanes out decades in a row.

Sea ice is melting around Alaska. We are watching native village peoples have to be moved. How many times would you like to move them? Do you sit there and decide in advance to move them slowly? Do you do it in one particular lump, as the sea ice is gone, and the waves start pounding the coast, and in the buildings go? It seems to me it would be nice, and it is a relatively small investment, when you consider the costs of moving infrastructure, to sit there and try to do this in some particular intelligent manner.

The Colorado River Compact was one that was negotiated based on a time period of rather abundant rainfall. Will we have to look at this again, and wouldn't we rather do that, instead of looking at a limited record, with some larger understanding of climate change?

So, I think it is just an enormous, enormous potential, if we can start connecting climate to society.

Ms. WOOLSEY. Okay.

Chair BAIRD. Thank you, Ms. Woolsey. I appreciate you following that line of questioning. Having grown up and studies in the Colorado River basin, the entire basin ravaged for years by political infighting that grew out of having, as I understand it, divvied up the water in a fairly record high water year, and so, promising water that didn't, then, later exist, and it has been really years and years and years of litigation and conflict and inadequate water supply.

I will recognize Mr. Tonko for five minutes.

Mr. TONKO. Thank you, Mr. Chairman. Dr. Barron, you touched upon this in your most recent response, but I represent a District that has many communities along a historic waterway.

RESPONDING TO CLIMATE INFORMATION

The advantages of a system that is optimum, as you would define it, be it State, regional, and national in design, how can we emphasize prevention, to avoid certain flooding, and then, how can we respond in mitigation terms? What would you envision to be the modeling out there that would enable communities to better avoid floods, and then, to better respond to floods? How would that infrastructure work? Because it seems to be a repeated pattern, with the extremes of climate change, that more and more communities are impacted by flooding of rivers, and intracoastal waterways.

Dr. BARRON. Yes. I gave the example in human health, to think broadly and cross regions, but I think an example that you have

just selected, it points to how important it is to have a community of scientists to interface with that are local and regional, because so many of those examples are examples by which the way you build infrastructure makes an enormous amount of difference, in terms of your vulnerability. And I think that this whole notion of building resilience into communities, by understanding this, makes an enormous amount of difference.

So, this is where this system needs to couple that on a global scale and a regional scale, and understanding how the system might change through global models, and coupling those with weather forecast models. But taking yourself right down to that local and regional level, because all of these problems, when you come right down to it, are local. But we are now being affected by local decisions as well as global decisions.

Mr. TONKO. I was just going to ask if anyone else has a response.

Dr. MOTE. I would like to emphasize that in addition to better modeling to characterize the physical system, which both I and Dr. Barron emphasized earlier, we need vigorous social science research to understand how decisions are made, the decision context, how to provide information that is actually useful, and will be used to make better decisions. And this is a component of this whole enterprise, that is, and I say this as a physical scientist, degree in physics. This is a part of this that is greatly neglected in the current climate science enterprise.

Dr. DEGAETANO. If I may.

Mr. TONKO. Yes, please.

Dr. DEGAETANO. Actually, your question was pretty timely, because Monday, I'll be traveling to Norrie Point, which is either in your District, or just south of your District, to address that very issue.

We are working with DEC and a number of entities within New York State, to look how sea level rise will manifest itself up the Hudson River, to look at infrastructure along the river, to look at different control mechanisms that might be put in place between, up the river, a true interdisciplinary effort between hydrologists, social scientists, through the Rising Waters Program, which is out of the Hudson River Estuary Commission.

So, those types of things are things that you know, any of our organizations are involved with, and are starting to work with now.

THE MODEL COORDINATING AGENCY

Mr. TONKO. So, the model that best coordinates all of that would look like what? Is there, who brings all the agencies, obviously have to have input here together, and then, how is it connected to the local planning or response effort?

Dr. DEGAETANO. I am probably not the best one to say who brings all the agencies together, but I think this is a good example of how the system needs to work. For instance, you need the local knowledge and expertise to know what is going on on the Hudson. You need the local expertise to do the modeling of what is going to happen in the Hudson River basin. The basin, the hydrology is very different than other river basins, so you can't just take some river model off the shelves. So, those are the local components.

On the national scale, you know, do you use my sea level rise projection, or do you use somebody else's? There, you need the coordinating efforts to make sure the data, either the observed data or the projections that go into these types of things, are consistent, that those types of things that come into play are there, that authoritative voice to say that this sea level rise projection, or this suite of sea level rise projects, manifest themselves his way on the Hudson River, and has this implication.

Mr. TONKO. Thank you.

Chair BAIRD. Thank you, Mr. Tonko. Dr. Mote, I appreciate your observation about social science. As my colleagues know, I am a social scientist. And I was down at AOML a couple years ago, and they were talking about the need for more supercomputing to predict hurricanes, but someone pointed out that even if we, the basic, we looked pretty good at Katrina, but you know, magnitude, timing, location, pretty accurate. But even if we had to the date, the moment, the magnitude, 50 percent of the people still wouldn't evacuate, and that is a social science problem, so I appreciate your raising it.

Ms. Edwards is recognized for five minutes.

Ms. EDWARDS. Thank you very much, Mr. Chairman, and thank you to the panelists. I am sorry I actually missed Dr. Lubchenco, because I had a chance to spend some time with her out at NOAA, to learn in a lot more detail about the work that is going on there, both in weather forecasting, but also, the range of work that the Agency already does in climate, and was really impressed by the work going on at that facility and the others around the country.

SUGGESTIONS FOR CHANGES AT NOAA

My question, really, for Dr. Barron is to ask you, given what may be deficiencies or inadequacies in, you know, the current wide range of climate activity going on across the spectrum of the Federal Government and the private and academic sector, if NOAA were to retain the role of, or gain the role of, essentially the federal kind of coordinator of Climate Service activities, what do you think would be the essential thing that needs to change within NOAA, to be able to take on this activity? And I am also curious to know what you think NOAA's strengths are, in being able to gain that responsibility?

Dr. BARRON. Okay. In many ways, I think NOAA is the natural lead, as I said, because of both their current effort in providing services, and because they have pieces here that they fund, National Climate Data Center, the RISAs, and those activities.

The reason why our group said it is not enough is because, I will give you just one example, and that is that if you go around the table, and I had a meeting with OSTP, in which 40 people representing 15 agencies were there, resource managers, they were asked the question what do you need first? And they all said regional climate predictions. Those become essential, because they get closer to the decisions.

Now, we don't have the computer power to do a very high resolution global climate model, but we have the capability to imbed weather models within climate models, and then provide, with that global model input, a weather forecast 30 years out, 40 years out,

not stating the day, but those conditions would yield this type of weather. And we could simulate things like hurricanes.

So, we know we are going to have to couple those capabilities, and within NOAA, these are quite separate. So, we have to find a way to have the conversation occur within NOAA that helps promote synergism between the modeling components. That is one example.

The other example I think we see is that that connection to users is now being done through a RISA, or providing data that is sitting out there, that a private company can grab, and we are going to move into a climate mode where private companies are going to want to grab that data, but there is also an enormous number of things by which that whole community hasn't had decades of weather forecasts to be able to say, oh, I am interested in that. That will affect what I want to do in this particular——

Ms. EDWARDS. Let me just interrupt you, because I think those things may be true, but it seems to me and others, you know, have an opportunity to comment on this, that some of that is also a resource question, and a need to coordinate information and data, and so, it is not so much about where the house is, but what the pieces need to be, you know, what is the structure.

And I look at, for example, on Weather Service, and thinking only in my lifetime, the evolution of how we have come on Weather Service, where we have been able to get down to that regional level, where people, if you talk to them in communities, I mean, maybe it is not such a bad idea that they think that their local weatherperson is the weather predictor. That is just because the information has been made usable and accessible, and so, I don't know that there is anything that is an institutional barrier within NOAA, that would not enable us to thoughtfully figure out a way to bring that under a house, so that our weather and our climate predictions and forecasts are connected.

And I wonder, in my limited time left, if there are others on the panel who have a response to that?

Dr. MOTE. Well, if I might, it really needs to be all about the users, so it is not just about providing information, and there are many other agencies that are responsive to the users. And so, it really goes beyond the NOAA. I agree with Dr. Barron. There needs to be a really high level, a multi-agency partnership.

Ms. EDWARDS. Mr. Chairman, I will yield, and I will just say, just in closing, that it does seem to me that as we go forward, for this Congress to provide the kind of oversight that we need to, it will be very complicated, I think, for us, reaching over several different stretches of the Federal Government, to figure out who is on first.

Chair BAIRD. I appreciate that, and I think, gentlemen, you are probably getting a sense from the Committee, we recognize fully, and I think your testimony, and that of Dr. Lubchenco, has really illustrated the need and the value for this information. I think there is an appreciation on the part of the Committee Members that, based on your testimony, that it needs to be better integrated, better distributed, better coordinated, et cetera, that there are multiple different entities within the government that are now doing parts of this.

I think, though, what we are all struggling with a little bit, I think, this is in line with Ms. Woolsey's question, Ms. Edwards' as well, is how does it all fit together? If you, and the bottom line for us is, if we write a bill, which we intend to, to create some form of climate service, what should that look like? Where do the pieces fit together? How is it coordinated?

And we have another panel. I think you are, Dr. Mote and others have talked about the importance of users. We will move very shortly to the next panel, but I would invite you to do this. So often in these Committee hearings, and it is true throughout the Congress, what happens is we ask you for your testimony. We ask questions, and then, we don't see you again for a really long time, if ever. And you don't necessarily always get to follow up with input about what the other, what other panelists suggested. So, I would invite you to give us followup testimony, if you will, based on, if you feel the need to further elucidate the questions we asked you, or to respond to what a colleague on the panel may have said. Say, here is, you know, so-and-so said this. This is where I agree, this is where I disagree, here is an alternative synthesis or divergence.

Please do that for us, and if you can do it in a very timely manner, that would be most appreciated, because my hunch is you have all spent a lifetime working on this. We have read the testimony. We have had this discussion. We want to do something right. We want to follow the dictum of do no harm. We believe something needs to be done.

So, if you can follow up in that fashion, it would be most appreciated. And unless anyone has any burning issues for this panel, and we may submit to you, it is customary at the end of these hearings to say the record will be open for two weeks, we may also follow up and say some more honing in points on, ideas on this.

[The information submitted by Dr. DeGaetano follows:]

Dear Mr. Chairman,

Thank you for the opportunity to clarify my response to the question that was posed by the committee concerning the difference between the roles of the Regional Climate Centers (RCC), Regional Integrated Sciences and Assessments (RISA) and the State Climatologists (SC). The role of the Regional Climate Centers is the operational delivery of services to regional stakeholders. The RCC do this through developing operational decision tools, providing and maintaining an operational computer infrastructure and direct services to users from diverse sectors. The RISAs conduct basic and applied social and physical science research focused on specific issues or stakeholders. The SCs provide services at a state level, they are generally authorized by state entities and hence are a source of climate expertise to state government. The table below, highlights some of the specific roles that each organization fulfills.

RCC
Operational providers of climate products and services to regional stakeholders and federal partners
Develop federal and state climate information systems
Link historical and near real-time data to decision support models
Integrate federal climate observations with regional and local observations
Improve the quality of climate data through development of QA/QC systems
Improve national climate monitoring efforts using regional information and expertise
Develop sector specific decision support tools addressing climate variability and adaptation
Applied Research; data quality improvement, derived climate parameters and indices, decision support tools, sector specific integrated topics, climate information systems
RISA
Fundamental climate impacts and adaptations research
SC
Direct climate service to local stakeholders
Provide climate information support to state agencies
State climate data collection systems; deliver data to regional data systems
Media interaction for local climate events and conditions
Local scale climate monitoring

Chair BAIRD. With that, I want to thank our witnesses for a very informative and thought provoking discussion, and for your many years of service, all of you, in your respective roles, on an ongoing basis, that have helped serve the country and this Congress and constituents.

We will adjourn this, recess, not recess, we will excuse this panel, and invite the next panel up. Take a very, very brief break while the names are switched around by our capable staff.

Panel III

Thank you again. Be seated, and we will begin very, very shortly with our third panel. I appreciate your patience. I think it is a very constructive structure we have here, I hope, with the folks who provide some of the information, and some of the recipients and utilizers, and people who apply that. And that is the main focus of panel three, and let me introduce that panel.

Dr. Michael Strobel is the Director of the National Water and Climate Center for the United States Department of Agriculture. Mr. Paul Fleming, the Manager of the Climate and Sustainability Group for the Seattle Public Utilities. Dr. Nolan Doesken, or Mr. Nolan Doesken. Did I say the last name right?

Dr. DOESKEN. Doesken.

Chair BAIRD. Doesken. Thank you, Dr. Doesken, the State Climatologist for Colorado, and a Senior Research Associate at Colorado State University, the alma mater of my father, by the way. Spent some time in Fort Collins.

And I would now like to recognize my friend from California, Representative Lynn Woolsey, to introduce Mr. Behar.

Ms. WOOLSEY. Well, Mr. Chairman, I am going to take a lot more time on Mr. Behar than you did on all these together. Is that all right?

Chair BAIRD. Well, that is sort of the custom here.

Ms. WOOLSEY. All right.

Chair BAIRD. We introduce them, and the local folks get a little extra time.

Ms. WOOLSEY. My guy, I work for him, so I will take better care of him.

Mr. Chairman, it is my pleasure to introduce one of my constituents, someone I work with, work for in my District. He is here today to testify before our committee. His name is Mr. David Behar. David's career spans over 20 years in environmental policy and water utility management. He currently serves as Deputy to the Assistant General Manager, Water Enterprise, at the San Francisco Public Utilities Commission, the SFPUC.

Mr. Behar developed the SFPUC-sponsored Water Utility Climate Change Summit, held in San Francisco in early 2007, and he currently serves as Staff Chairman of the Water Utility Climate Alliance. From 1991 to 1997, he served as the Executive Director of the Bay Institute of San Francisco, and from 1989 to '91, he served on the staff of U.S. Senator Alan Cranston, a Democrat from California. In November of 2006, David was elected to the Board of Directors of the Marin Municipal Water District, a district with 200,000 customers, just north of San Francisco, in my District, in Marin County.

David lives with his two children in Marin County, and I am pleased to welcome him here today in Washington, D.C.

Chair BAIRD. Thank you, Ms. Woolsey. I appreciate that. We all serve all these people, whether or not we are——

Ms. WOOLSEY. Oh, well.

Chair BAIRD.—privileged to have you in our District, we are honored to have you here today.

We will proceed in questioning, witness statements from Dr. Strobel and across, through the panel. With that, I will begin with Dr. Strobel. Thank you.

STATEMENT OF DR. MICHAEL L. STROBEL, DIRECTOR, NATIONAL WATER AND CLIMATE CENTER, NATURAL RESOURCES CONSERVATION SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE

Dr. STROBEL. Good morning, Chairman Baird, Ranking Member Inglis, and other Members of the Subcommittee. Thank you for the opportunity to testify today about the climate data collection and analysis activities of USDA's Natural Resources Conservation Service. My name is Michael Strobel. I am the Director of NRCS' National Water and Climate Center in Portland, Oregon.

NRCS has been a leader in climate services to assist agricultural activities and natural resource conservation since 1935. In that year, the Soil Conservation Service, which NRCS was then known as, established a formal, cooperative snow survey and water supply forecasting program. The Snow Survey Program has grown in scope and in number and diversity of users that rely on the water supply forecast developed by NRCS.

In addition to the Snow Survey Program, the National Water and Climate Center also manages the Soil Climate Analysis Network, or SCAN, a soil moisture and climate information system designed to provide data to support natural resource assessments and conservation activities. I will briefly discuss SCAN later, but I will spend the majority of my time discussing the Snow Survey and Water Supply Forecasting Program, how it works, why it is important, and who uses that information.

Depending on the geographic location, 50 to 80 percent of the annual water supply in the West arrives in the form of snow. The NRCS' Snow Survey Program is a main source of data on high elevation snowpack in the West. Data on the depth and density of the snowpack provide critical information to decision-makers and water managers throughout the West. NRCS works hard to ensure that consistent and reliable water forecasts are available for a wide variety of uses throughout the year.

Since 1935, the Snow Survey Program has grown into a network of almost 2,000 snowpack monitoring sites in 13 Western states, including Alaska. More than 1,200 of these sites are manually measured snow courses. Either an NRCS employee or an employee of a partner organization must visit each manual snow course site once a month during the snow season, and take snowpack measurements manually. The remaining 760 sites are automated snowpack telemetry, or SNOTEL, climate stations, which do not require monthly visits, but provide real-time snowpack information via Meteor Burst technology.

In the future, we will continue to increase the percentages of snow survey sites that are automated. This would result in more accurate water supply forecasts and snowpack reports, as well as a decrease in the safety risks for NRCS employees and partners who monitor remote sites in what can be sometimes challenging winter conditions.

NRCS employees use the manual snow course and automated SNOTEL data, as well as modeled water supply and streamflow volume data to develop streamflow forecasts for over 740 locations in the West. These forecasts help reduce the uncertainty for users making everything from long-term strategic decisions regarding multi-year water supplies to immediate emergency response decisions in times of high streamflows.

Let me give you a few concrete examples of how our customers use our water supply forecasts. Agricultural producers use our forecasts to manage drought risk, make cropping decisions, and determine irrigation allotments. Wildlife conservationists use streamflow forecasts to help manage habitat for threatened and endangered species. Climate researchers use snowpack data to develop climate change risk assessments for long-term water availability. Municipal officials use snow survey data and analysis to

manage reservoir levels in Western towns and cities. The National Weather Service's River Forecast Centers depend on Snow Survey data for the snowpack component of their data analysis and forecasting systems. And recreation is a key industry in the West. Ski resorts, river rafting companies, and others use our data and forecasts to operate and manage their facilities. I hope I have given you a sense of the number and diversity of end users that rely on our Snow Survey and Water Supply Forecasting information.

The National Water and Climate Center also manages SCAN, the Soil Climate Analysis Network, which was started as a pilot program in 1991. SCAN has evolved into a cooperative system that monitors soil moisture and other climate parameters, and makes the data available to users on a real-time basis. The system is used primarily for monitoring and mitigating the effects of drought and flooding. The current SCAN system consists of 150 stations located in 39 states across the U.S.

In summary, NRCS' climate services produce critical data, forecasts, and analysis for a wide variety of public and private uses. Users rely on NRCS' near real-time data and unbiased forecasts to plan and execute short and long-term decisions, ranging from individual farmers planting dates to basin-wide water management planning.

Thank you again, Mr. Chairman, for the opportunity to appear before you today, and I would be happy to respond to any questions.

[The prepareed statement of Dr. Strobel follows:]

PREPARED STATEMENT OF MICHAEL L. STROBEL

Mr. Chairman, thank you for the opportunity to testify today about the USDA Natural Resources Conservation Service's climate data and analysis activities. My name is Michael Strobel and I am the Director of NRCS's National Water and Climate Center in Portland, Oregon. The Center directs NRCS's climate services.

Our understanding of a climate service is an activity to inform the public through the production and delivery of authoritative, reliable, timely, and useful information about climate to enable the management of climate-related risks and opportunities related to impacts. Resource management agencies and departments, including USDA, have responsibilities in preparing the Nation to adapt to climate change and will be important clients of improved information about the climate and expected climate changes.

NRCS has been a leader in climate services to assist decision-making associated with agricultural activities and natural resource conservation since 1935. In that year, the Soil Conservation Service (as NRCS was then known) established a formal cooperative Snow Survey and Water Supply Forecasting (SS–WSF) Program. Since that time, the SS–WSF has grown in scope and in the number and diversity of users that rely on the water supply forecasts developed by NRCS. In addition to the Snow Survey program, in 1991 the National Water and Climate Center began a pilot program that later turned into the Soil Climate Analysis Network (SCAN), a soil moisture and climate information system designed to provide data to support natural resource assessments and conservation activities.

I will now discuss the Snow Survey Program and SCAN in more detail—how they work, why they are important, and who uses the information.

SNOW SURVEY and WATER SUPPLY FORECASTING

From its beginnings in 1935, the SS–WSF Program has grown into a network of more than 1,200 manually-measured snow courses and over 750 automated Snowpack Telemetry (SNOTEL) weather stations in 13 Western states, including Alaska. The SS–WSF Program provides water supply data; modeled water supply and streamflow volume data; and streamflow forecasts for over 760 locations in the West. SNOTEL is a reliable and cost effective means of collecting snowpack and other weather data needed to produce water supply forecasts used by water man-

agers in the west from irrigators to municipalities. The data and information is also important in achieving the objectives of the Western Governors Association as noted in their report, *Water Needs and Strategies for a Sustainable Future.*

With 50–80 percent of the water supply in the West arriving in the form of snow, data on the snow pack provide critical information to decision-makers and water managers throughout the West. The basic data becomes even more valuable when used in concert with partner organizations to provide water supply forecasting tailored to meet end-user needs.

Reliable information helps reduce the uncertainty in making critical environmental, agricultural, industrial, and municipal management decision regarding annual and multi-year water supplies and streamflows within specific watersheds and sub-basins in the western United States. These decisions may be long-term strategic-planning decisions; logistical, tactical, and operations planning decisions; short-term planning decisions; or immediate, emergency decisions.

Below are examples of how customers use SS–WSF data and analyses:

- Reservoir management
- Irrigation water management
- Cropping decisions
- Crop futures forecasting
- Risk management related to agriculture in general and agricultural finance in particular
- Planning and scheduling of water-related business or government activities
- Flood damage reduction
- Drought risk reduction
- Climate change risk assessments for long-term water availability
- Emergency response and emergency preparedness
- Protection of threatened and endangered species
- Power generation and other energy contracting and management
- Recreation management and other recreation-related decision-making
- Municipal and industrial water supply management

CASE STUDIES OF NRCS CLIMATE SERVICES USERS

SS–WSF data and related reports and forecasts are made available-in near real time for the automated SNOTEL sites-to private industry; to Federal, State, and local government entities; and to private citizens through an extensive Internet delivery system and other distribution channels. Following are some examples of how these data and reports are used by NRCS customers.

Case Study—Agricultural Producers

Despite the great variety of agricultural operations in the Western U. S., a common denominator is some degree of dependence on a diverted or stored water supply. In some areas, snowpack is the only significant water storage available. In other areas, reservoirs provide a means of stretching water storage into the summer and sometimes into the fall growing and harvesting seasons.

In southern Idaho, producers in the Salmon Falls and Twin Falls irrigation tracts rely on SNOTEL data and stream forecast information as input in making decisions about what, when, and how much to plant. Irrigation district managers within this region use SS–WSF data and forecasts early in the season to inform their water users on the percentage of their full irrigation allotment they should expect to receive in the upcoming growing season. These irrigation allotment predictions are based on SS–WSF data that show (1) the probability of varying levels of water supply given existing snowpack, soil moisture, and water content; and (2) historic probabilities for additional snowpack and water content accumulations.

These reports are crucial to producers who use them to make cropping and operation decisions well in advance of the growing season. Based on modeling of the typical cropping patterns in the area for a 160-acre farm, the value of the SS–WSF data to producers in this region is estimated as ranging from $27 per acre in a normal year to $111 per acre in a water short year. Based on irrigated acres in those areas, the total value to producers is estimated to be as much as $21.8 million in a water short year.

Case Study—National Weather Service River Forecast Centers

The National Weather Service (NWS) operates River Forecast Centers (RFCs) covering all of the landmass of the U.S. In the mountain regions, the RFCs produce river flow, flood prediction, and other hydrologic and weather-related data products for the Western regions of the U.S. and part of lower British Columbia. They depend on NRCS SS–WSF data for the snowpack component of their data analysis and forecasting systems.

The river forecasts, along with NWS flood warnings, help save lives and give communities time to take appropriate actions to lessen flood damage. SNOTEL data is used to validate and adjust the amount of snow and snowmelt simulated in a hydrologic model which produces more accurate forecasts of river flows. These daily river forecasts are also used during non-flood periods for recreational purposes (rafting, kayaking, fishing, etc.).

Case Study—Recreation Industry

Recreation is an important industry in Western States and many categories of tourism and recreation are—in one way or another—dependent on or affected by either snowpack levels, water supply volumes, or both. Potential commercial and private users of SS–WSF data include recreation associations, hunters, fishermen, boaters, skiers, snowmobilers, campers, tourists, and others whose recreational activities or travel plans might be affected by snow depths or streamflows.

An outfitter operating a river rafting business in the Intermountain West reported that SNOTEL data had indicated that river conditions would render their traditional rafting equipment inoperable in the 2002 season—ultimately the worst season on record for rafting in the area. Based largely on SS–WSF information, the firm purchased smaller craft that would be operable in the environmental conditions predicted by the data. Without the advantage of streamflow projections prior to the beginning of the rafting season, the low water levels would have resulted in a year with little to no revenue. Instead, the decision to purchase the smaller craft resulted in a $600,000 revenue year.

Case Study—Denver Water Board

Power, utility, and water companies use the SS–WSF data in their daily operations and long-range planning decisions. They can also use the data in forward contracting for purchasing and selling power in the wholesale market.

The Denver Water Board uses SNOTEL real-time snowpack and water supply forecast information as input for their reservoir management decisions. If decisions were based only on the historic water supply averages, the Board could lose as much as $5.5 million annually in potential revenue due to sub-optimal transfers of water between the various storage reservoirs within their collection and distribution system.

SOIL CLIMATE ANALYSIS NETWORK

Started as a pilot program in 1991, the Soil Climate Analysis Network (SCAN) has evolved into a system supported in part by NRCS and by various federal, State, local, tribal and university groups that assist in funding and field operations. SCAN monitors soil moisture and other climate parameters and makes the data available to users on a real time basis. The system is used primarily for monitoring and mitigating the affects of drought and flooding. The current SCAN system consists of 150 stations located in 39 states.

National resource management issues for which long-term soil-climate information is needed include:

- Monitoring drought development and triggering plans and policies for mitigation.
- Predicting changes in runoff that affect flooding and flood control structures.

Here are a few examples of how SCAN data are used across the Nation:

- The Newby Farm SCAN station in Alabama helps poultry farmers monitor local conditions so they can mitigate odor issues when managing poultry waste.
- Data from 15 SCAN sites in Mississippi are used by local farming communities near each site to determine when soil temperature and soil moisture are optimal for planting.

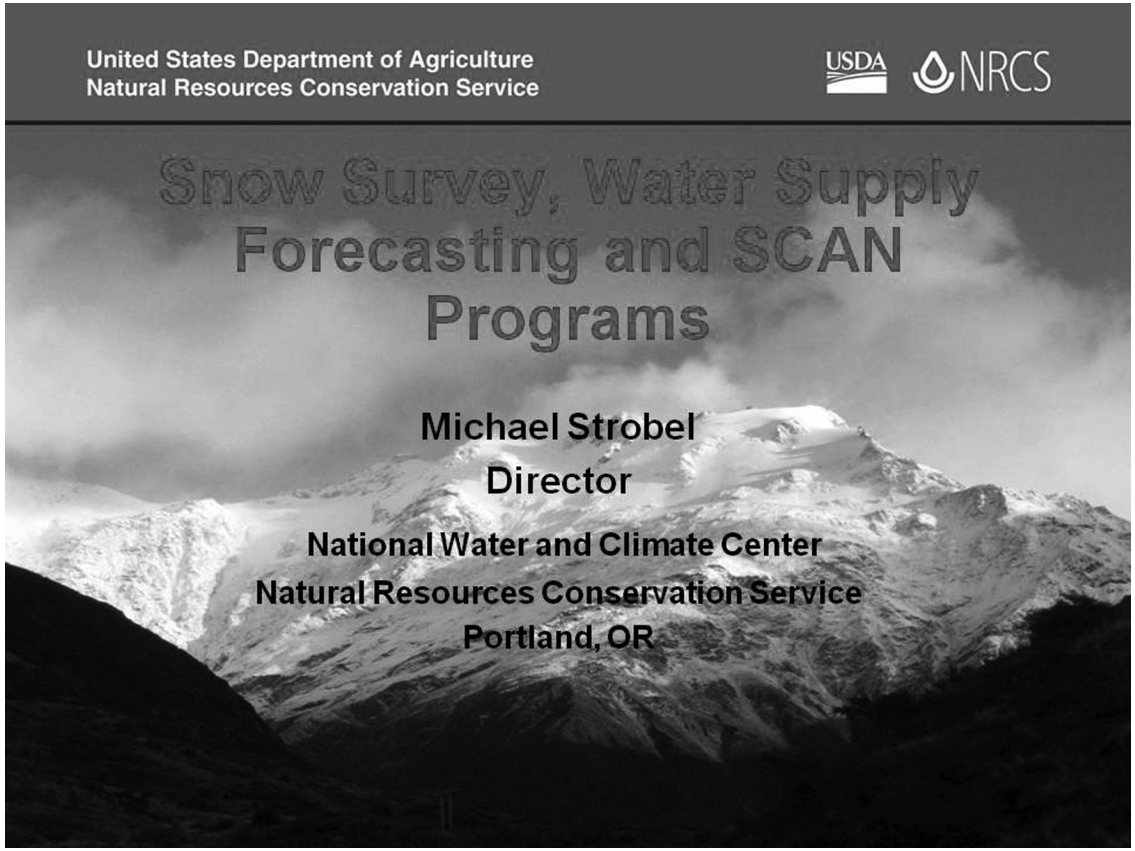
NRCS's National Water and Climate Center works closely with the NOAA/USDA Joint Agricultural Weather Facility (JAWF), located in USDA's Office of the Chief

Economist. JAWF meteorologists monitor weather conditions and crop developments on a daily and seasonal basis, and prepare agricultural assessments for USDA commodity analysts and the Office of the Secretary of Agriculture. JAWF relies heavily on SCAN data for U.S. soil temperature maps which are published in the Weekly Weather and Crop Bulletin; temperature and precipitation data used in the U.S. Drought Monitor which is also released every week and followed closely by decision-makers; and weekly agricultural weather information disseminated by the USDA Stoneville Data Center to the agricultural community.

The National Integrated Drought Information System (NIDIS), an interagency, multi-partner approach to drought monitoring, forecasting, and early warning led by the National Oceanic and Atmospheric Administration (NOAA), builds on existing systems infrastructure, data, and operational products from various agencies. For example, it incorporates data from the SNOTEL (SNOw TELemetry) network of USDA's NRCS.

SUMMARY

NRCS climate services produce critical data, forecasts and analyses for a wide variety of public and private users. Users rely on NRCS's near-real time data and unbiased forecasts to plan and execute short- and long-term decisions ranging from individual farmers' planting dates to basin-wide water management planning. In the future, we hope to increase the percentage of Snow Survey sites that are automated. This would result in more accurate water supply forecasts and snow pack reports, as well as decrease the safety risks for NRCS employees who monitor remote sites in challenging weather conditions. Thank you again, Mr. Chairman, for the opportunity to appear before you today, and I would be happy to respond to any questions.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Natural Resources Conservation Service
USDA
NRCS
Snow Survey, Water Supply Forecasting and SCAN Programs
Michael Strobel
Director
National Water and Climate Center
Natural Resources Conservation Service
Portland, OR

United States Department of Agriculture
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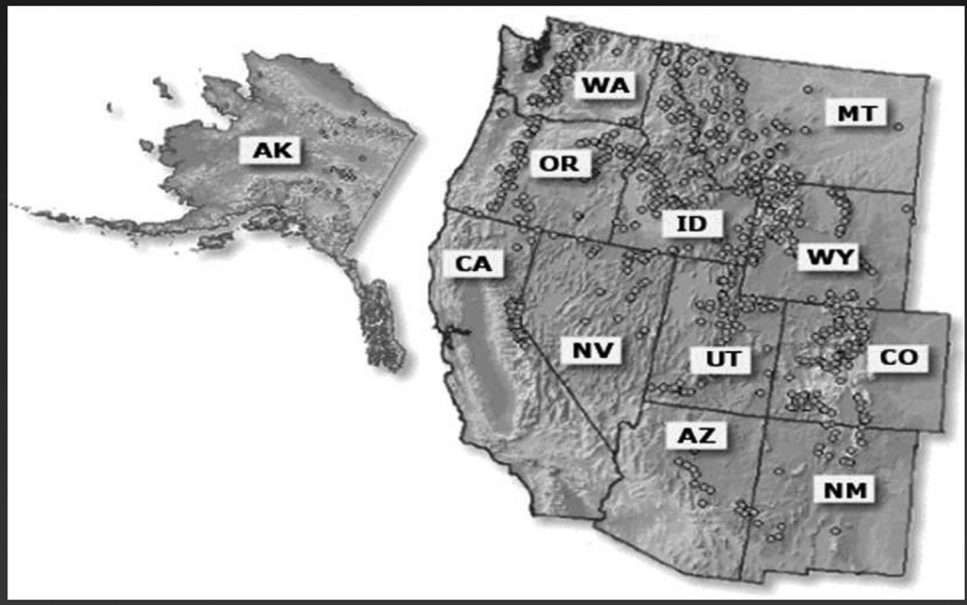
USDA NRCS

Snow Survey and Water Supply Forecasting Program



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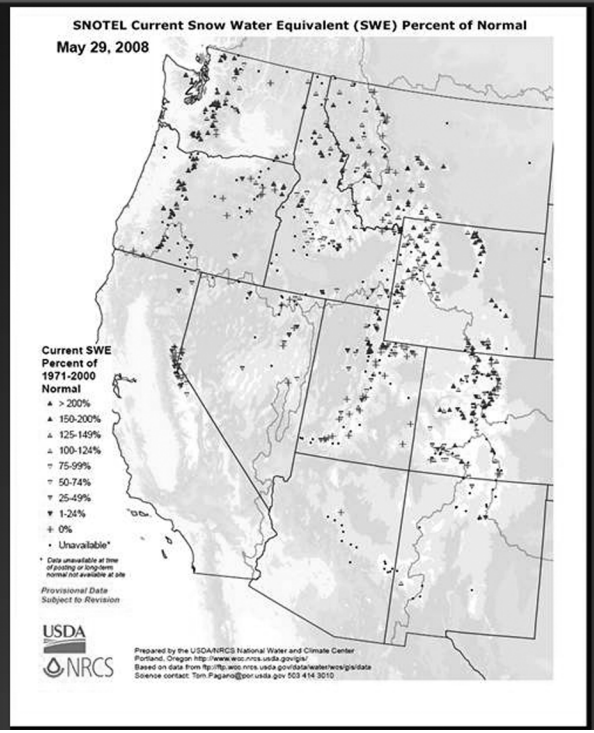
NRCS SNOTEL Network



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Winter SNOTEL Site

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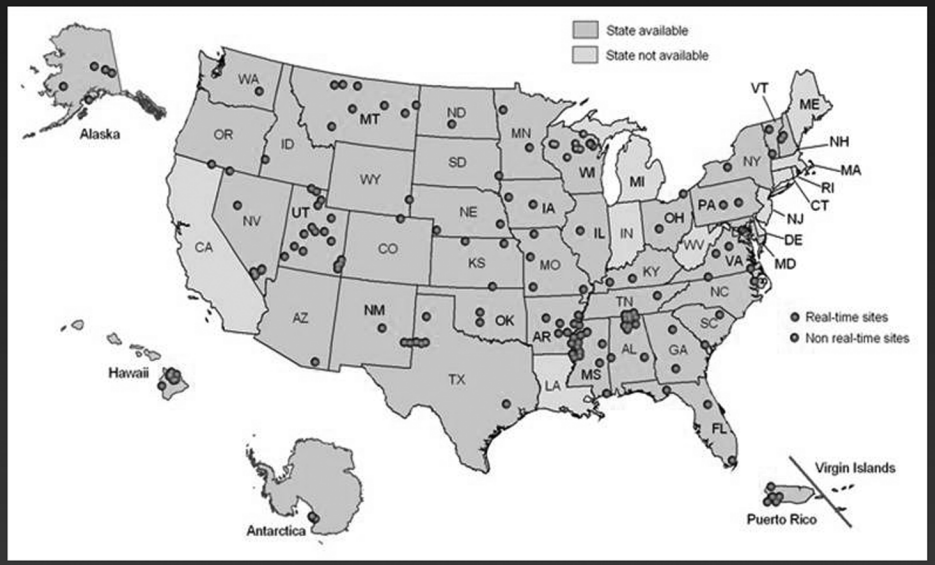
Natural Resources Conservation Service

USDA NRCS

Soil Climate Analysis Network



United States Department of Agriculture
Natural Resources Conservation Service

USDA NRCS

BIOGRAPHY FOR MICHAEL L. STROBEL

Dr. Strobel received B.S. and M.S. degrees in Geology and Mineralogy from the Ohio State University in 1985 and 1990 and a Ph.D. in Geology, specializing in hydrology, from the University of North Dakota in 1996. From 1983 to 1988 he worked in the field of glaciology for the Byrd Polar Research Center and conducted field work in Antarctica, Greenland, Peru, and Alaska. He joined the U.S. Geological Survey in 1988 and served as a hydrologist in Ohio, North Dakota, South Dakota, North Carolina, and Nevada. He was Deputy State Director for the Nevada Water Science Center for almost six years. Dr. Strobel authored the book Water in Nevada which provides non-scientists a primer on basic hydrology. He served on the Board of Directors for the Nevada Water Resources Association and was Chief Editor of the *Journal of the Nevada Water Resources Association.* Since June, 2007, he has served as the Director of the National Water and Climate Center, NRCS, in Portland, Oregon. The Center oversees the Snow Survey and Water Supply Forecasting Program, which operates over 750 automated snow telemetry (SNOTEL) sites and 1,200 manual snow courses in 13 Western States, including Alaska. The Center also operates the Soil Climate Analysis Network (SCAN) that has stations in 39 States and U.S. territories. SCAN provides data at a national scale for climate assessment and drought mitigation.

Chair BAIRD. Thank you, Dr. Strobel. I envy your work. I would love to spend some days up looking at snow sites from time to time.

Dr. STROBEL. It is a great job.

Chair BAIRD. And you do great work for the Northwest. I am grateful for it. Thank you.

Mr. Behar.

STATEMENT OF MR. DAVID BEHAR, DEPUTY TO THE ASSISTANT GENERAL MANAGER, SAN FRANCISCO PUBLIC UTILITIES COMMISSION

Mr. BEHAR. Thank you, Mr. Chairman. Thank you, Ranking Member Inglis, Members of the Committee, and of course, Congresswoman Woolsey. Thank you very much for that introduction. I will go back and report to our constituents, who know and love and respect your work very much that you are on top of climate change issues, as you are, and that matter so much to all of us in Marin.

I appreciate the opportunity, Mr. Chairman, to come and speak from a stakeholder perspective about the need for a National Climate Service. I have been introduced, SFPUC has 2.5 million water customers in the Bay Area. We are the sixth largest municipal district in the country, and as Ms. Woolsey mentioned, we are also a founding member and coordinate the Water Utility Climate Alliance, which is a consortium of eight large water utilities from around the Nation, serving more than 36 million customers. It is focused exclusively on adaptation, the adaptation challenges we face in the water industry.

According to two recent EPA reports to Congress, water and wastewater utilities together will need to spend about $480 billion over the next 20 years or so upgrading our systems to keep them in a state of good repair. The figure does not include responding to climate change challenges, but we know that all of those investments in new assets will be made as our climate is changing. However, as has been mentioned, many of today's climate change projections are so uncertain as to be difficult to use in planning how we purchase those assets, and planning how we spend those funds on our systems.

And that is why, when it comes to climate change science, water utilities are looking for what WUCA members have begun to call actionable science. We define actionable science to mean "data analysis and forecasts that are sufficiently predictive, accepted, and understandable to support decision-making, including capital investment decision-making."

The term is intended to convey our understanding that perfect information on climate change is neither available today, nor likely to be available in the near future, but that over time, as the threats climate change pose to our systems grow more real, predicting those effects with greater certainty is a nondiscretionary choice that we need to make.

Now, if actionable science is one need, accessible science is another need. A National Climate Service, we believe, can provide access to science to those of us who are assessing our vulnerability, in an accessible fashion. I want to agree strongly with Dr. Barron, who said that from a stakeholder perspective, it can be difficult, at times, to get the kind of climate information that we need to plug into our operations models, and begin to think about what our adaptation challenges actually are. I have seen from my experience at both the PUC, and as a Director at MMWD, how difficult it can be to access sound science, and to know what it is you are actually accessing. Even relatively sophisticated water agencies are having a difficult time answering the most basic questions related to what climate challenges we actually face in the long-term, which is the asset investment strategy that we have to think about.

I want to also commend Dr. Barron and the Science Advisory Board that NOAA asked to put together its options for developing a National Climate Service report. The report identified key attributes of a National Climate Service that I think are worth citing for a moment.

It said: "The Service will achieve its mission by promoting active interaction among users, researchers, and information providers. The Service will be user-centric, by ensuring that scientifically based information is accessible and commensurate with users' needs and limitations." This has been echoed in some of the testimony so far you have heard today, and I want to agree wholeheartedly with that.

In our view, a powerful and responsive National Climate Service should be like a wheel, with a hub, which is our headquarters, and spokes, which are regional centers. Like a wheel, without the hub, the wheels come off. At the end of the spokes is where we think the rubber is going to hit the road. At the center, we need a federal family to come together, and create a cohesive federal structure that supports the NCS mission. We want to see lessons learned from the example of the U.S. Climate Change Science Program, which has produced a tremendous amount of important research, but has, at times, been criticized for failing to achieve a consistent and transparent vision for that research, and also, for struggling, at times, to effectively engage the stakeholder community.

At the spokes of the wheel, stakeholders and researchers alike strongly believe that the success of an NCS mission, as others have said today already, depends on creating a robust and geographically distributed regional presence. Such a presence would feature

engaged, multi-disciplinary teams of physical scientists, social scientists, communication specialists, and modelers, that are located in the communities that are facing adaptation challenges. Those boots on the ground experts understand their region and its unique conditions, and are active participants in ongoing conversations with climate information users, folks like ourselves. And they aren't paratroopers, just to stretch the military analogy to its breaking point. They are actually part of the communities that they serve.

This decentralized, user-centric approach is far from unprecedented in the Federal Government. Many have talked about the RISA program. We agree that it is a model that can be expanded upon, improved, even made broader, with a more consistent mission across the United States, and perhaps provide a model for that geographically distributed approach that we think is so essential to reflect user concerns over adaptation, and bringing climate science out to our communities.

Thank you very much.

[The prepared statement of Mr. Behar follows:]

PREPARED STATEMENT OF DAVID BEHAR

Mr. Chairman and Members of the Committee, thank you for this opportunity to appear and present a stakeholder perspective regarding formation of a National Climate Service. My name is David Behar. I am the Deputy to the Assistant General Manager at the San Francisco Public Utilities Commission (SFPUC). The SFPUC is the sixth largest municipal water provider in the U.S. and manages water and power facilities that serve 2.5 million Bay Area residents, as well as wastewater and stormwater facilities in San Francisco. For the City and County of San Francisco, I also am helping develop a City-wide Climate Adaptation Plan encompassing all City departments facing climate change-related vulnerabilities, similar to programs underway in New York City, Chicago, and other cities across the U.S.

I also serve as Staff Chairman of the Water Utility Climate Alliance (WUCA), a consortium of eight water utilities dedicated to providing leadership and collaboration on climate change issues affecting drinking water utilities by improving research, developing adaptation strategies, and creating mitigation approaches to reduce greenhouse gas emissions. WUCA is chaired by SFPUC General Manager Ed Harrington and includes some of the largest water providers in the Nation serving 36 million Americans. WUCA members include Denver Water, the Metropolitan Water District of Southern California, New York City Department of Environmental Protection, Portland Water Bureau, San Diego County Water Authority, Seattle Public Utilities and the Southern Nevada Water Authority. In my spare time, I serve on the Board of Directors of the oldest municipal water agency in California, Marin Municipal Water District (MMWD), a position to which I was elected in 2006.

The Stakes for Water and Wastewater Utilities

According to two recent EPA reports to Congress, water and wastewater utilities in the U.S. will need to invest some $480,000,000,000 over the next twenty years to keep our systems in a state of good repair.[1] This figure does not include climate change response, but we know those investments will be made as our climate is changing, and the life cycle of those assets—including transmission lines, treatment plants, outfalls, urban drainage systems, dams—is measured in periods from several decades to over a century. This is the same timeframe for climate change projections that are commonly presented in the scientific literature. But many of today's climate projections are so uncertain as to be unusable as we weigh how best to spend that $480 billion. We need information on a host of climate parameters for which past hydrology is no longer an indication of future conditions. These include temperature, precipitation, changes in the mix of precipitation falling as rain and snow, changes in runoff timing, changes in demand, drought duration and frequency, extreme

[1] "Drinking Water Infrastructure Needs Survey and Assessment: Third Report to Congress." USEPA Office of Water, 2005. "Clean Watersheds Needs Survey 2004: Report to Congress." USEPA, January 2008.

events including storms and heat waves, and sea level rise. The models often don't simulate important aspects of climate successfully and don't agree with one another in terms of the scale of expected change and in some cases even the direction of change. A key issue is that the global climate models don't produce data at the temporal and spatial scale that we need to make decisions—that is, at the watershed and the sewershed levels. Of course, compounding the difficulty is the fact that, in the absence of national and international agreements on curbing greenhouse gas emissions, we face a multitude of emissions scenarios as well.

Water utilities, and others planning a response to climate change, are handcuffed by uncertainty—but we're not paralyzed. The challenge lies in taking steps today that make sense before factoring in the effects of climate change, but that also create resiliency to climate change in whatever form that change takes in the future. These we refer to as "no regrets" strategies. For many utilities but particularly in the growing but arid west, aggressive water conservation strategies have taken center stage, as are projects that diversify supply to include drought-resistant sources such as recycled water and conjunctive use groundwater programs. In San Francisco, for example, due to a combination of these programs, since the 1970's we have reduced our consumption of Hetch Hetchy water by 27 percent while population increased 13 percent. In Southern California, the Metropolitan Water District, a WUCA member and the largest municipal water agency in the Nation, has developed over the past 20 years 600,000 acre feet of conservation, 250,000 acre feet of water recycling, and over 100,000 acre feet of groundwater recovery and augmentation, while increasing local storage capacity by a factor of fourteen. Even as population has grown by 3.5 million, total water use in MWD's service area has actually declined.

But we know such strategies alone may not allow us to escape the projected effects of climate change on our water systems. And because it can take decades to plan, fund, design, permit, and construct new or renewed projects, we are thinking today about our infrastructure needs of 2030, 2050, and beyond.

"Actionable Science"

When it comes to climate science, water utilities are looking for what WUCA utilities call *"actionable science."* We define actionable science as

> Data, analysis, and forecasts that are sufficiently predictive, accepted, and understandable to support decision-making, including capital investment decision-making.

We've come up with this term to convey our understanding that perfect information on climate change is neither available today nor likely to be available in the future, but that over time, as the threats climate change poses to our systems grow more real, predicting those effects with greater certainty is non-discretionary. We're not yet at a level at which climate change projections can drive climate change adaptation. This makes us nervous—and it's not terribly comforting for our ratepayers either.

At least two things must happen from our perspective in the short-term to provide society with some reassurance at this early but ominous phase of climate change adaptation planning. First, we need increased investment in climate science that will, as swiftly as possible, provide local entities of all stripes with intelligence about the future that is of a quality and scale that meets the definition of "actionable." Second, partnerships must be built between local and regional entities whose systems are vulnerable to the effects of climate change and the research community (including social scientists, economists, and legal researchers), policy-makers, and others to assist those entities in understanding the range of futures they face and provide decision support in the face of less than perfect information.

Accessible Science: The National Climate Service

Today's hearing, on the subject of a National Climate Service, lies along the path, we hope, to providing "accessible science" to those who are assessing their vulnerability to climate change—and planning their adaptation response. These science "users" include water utilities, local governments, public health officials, parks and wildlife managers, coastal zone agencies, urban planners, farmers, homeowners, NGOs and other public and private sector interests.

I've seen from my own personal experience both at the SFPUC and as a board member at MMWD how difficult it can be to access sound climate information. Even a sophisticated water agency has difficulty finding answers to the most basic questions and accessing data compatible with their systems models. University researchers are busy teaching and publishing, agency staff in Washington, D.C. are un-

known to us, and those who we call "users" of climate information are often left to scramble haphazardly to collect tidbits of information from a multiplicity of sources as we seek to create resilient communities ready to adapt to the effects of climate change.

We commend the Climate Working Group of NOAA's Science Advisory Board for its thoughtful and focused report *"Options for Developing a National Climate Service"* (February 26, 2009). The report identified "Key Attributes" of a National Climate Service worth citing here:

> The Service will achieve its mission by promoting active interaction among users, researchers, and information providers. The Service will be user-centric, by ensuring that scientifically-based information is accessible and commensurate with users' needs and limitations. (p. 5)

We agree.

Several organizational options were outlined in this report and we concur with those who have suggested that each option contains elements of what a future NCS should look like.

In our view, a powerful and responsive NCS should be like a wheel, with a hub (headquarters) and spokes (regional centers). To leverage the metaphor a bit further: without the hub, the wheels come off. And at the end of the spokes is where the rubber hits the road.

An NCS, we believe, requires the support of a lead federal agency with budgetary authority and responsibility for critically important science and data management functions. It seems clear that NOAA, with its broad and deep expertise and responsibilities in these areas, is well positioned to assume this role. In addition, oversight, as well as coordination and cooperation between the lead and other federal agencies such as EPA, USGS, NASA, USDA, and others is critically important. We need the federal family to come together to create a cohesive federal structure that supports the NCS mission. Hopefully, lessons have been learned from the example of the U.S. Climate Change Science Program, which has been widely criticized for failing to achieve a consistent and transparent vision across the federal enterprise and for doing a poor job of engaging with stakeholders.

Stakeholders and researchers alike strongly believe that the success of an NCS mission depends substantially on creating a robust and geographically distributed regional presence. Such a presence would feature engaged, multi-disciplinary teams of physical scientists, social scientists, communications specialists, and modelers *in the communities facing adaptation challenges.* These "boots on the ground" experts understand their region and its unique conditions and are active participants in an ongoing and iterative conversation with climate information users that builds a familiarity that informs both sides. They aren't paratroopers, either—they are a part of the communities they serve.

For the user, we need an accessible go-to entity we can count on to help us sift through the ever-changing science, gather the raw data, benchmark against the experience of others, educate our publics, and work with us in assessing our vulnerabilities. In addition, all these players together will organically develop research partnerships with a responsive university community, bringing a "grass-roots science" approach that can complement the "Big Science" pursuits in the area of climate modeling and atmospheric and oceans science that underpin our understanding of global climate change. All this work should be part of a set of ongoing relationships, born of a shared mission that is at the heart of the term "service," between climate scientists and engineers, economists and rate administrators, oceanographers and urban planners, elected officials and agency managers.

These conversations are far from easy. I have attended workshop after workshop with climate scientists and decision-makers that are intended, like an arranged marriage, to create an advantageous union. Usually the climate scientists present their research. Then comes an uncomfortable silence. Usually one of the climate scientists who did not present makes a comment. Then we move on to the next presentation. At one recent workshop track I forced myself to announce that I didn't understand the last speaker's presentation, but it seemed important that at some point I do. It was like a great weight had been lifted from my fellow non-scientists in the room.

The greatest advances in multi-disciplinary understanding on the subject of climate change simply don't happen in one-off workshops. They take practice. They happen over time and are based on sustained relationships.

This decentralized, user-centric approach is far from unprecedented in the Federal Government. Closest to home, the NOAA-funded Regional Integrated Sciences and Assessments (RISA) program offers a notable demonstration model. These university-based partnerships, with very small but essential core funding from NOAA,

have done outstanding work in the Southwest, Colorado Basin, Pacific Northwest, California, and elsewhere. They have benefited many stakeholders that have had the good fortune to work with them and they are today at the heart of both general public and stakeholder education about climate change adaptation effects for water utilities and others. They bring the multi-disciplinary conversations and a science-meets-policy-meets-decision-making focus that we need. They are already the most useful spokes of our wheel.

A project Denver Water, another of WUCA's member utilities, is helping lead illustrates the power of the RISA model and how its expansion could pay dividends across the United States. To understand climate science and determine potential impacts to local hydrology, the water providers of the Front Range urban area of Colorado are collaborating on a cooperative regional study in partnership with the local RISA, the Western Water Assessment, led by the estimable Brad Udall, along with the National Center for Atmospheric Research, Water Research Foundation and the State of Colorado. The participating water providers supply water to nearly two-thirds of the population of the State of Colorado. Working with local researchers and climate change experts, the local RISA helped provide educational sessions, documentation, direction, and access to experts to help the water users understand climate change science and modeling, understand and obtain down-scaled global climate model projections, convert the projections into sets of planning scenarios, and assist with setting up local hydrology models to convert the global climate model projections into projected impacts on local streamflow. Being a regional entity, the local RISA was familiar with the regional climate projections, researchers, water systems, and water utilities. A federal climate agency without that regional connection and approach probably would not have been able or available to support a regional effort like this, making it much more difficult for water utilities to make use of climate science. The Front Range cooperative effort is today leveraging local cooperation with local *service* provided by a locally-based federal climate science boundary organization, the RISA.

The RISA program is not perfect, however, and expanding it exponentially will have to be done with care. For example, each RISA today has a different mission (and even a different name). Greater uniformity and clarity of mission within the program would make sense if the program model were to be expanded—while maintaining the flexibility of each office to respond to differing local and regional conditions.

In addition, expansion of the RISA program alone won't be sufficient. Data management, storage, and access depend significantly on centralized facilities that regional adaptation programs must have the ability to access. In addition, local relationships with regional arms of federal regulatory, land management, and operational agencies such as USGS, EPA, Bureau of Reclamation, USDA, the Fish and Wildlife Service, and the Army Corps will continue, and adaptation efforts must account for the need to work with these agencies both in Washington and in the field and regional offices.

Nonetheless, with an annual budget of the nine RISA programs at a mere $5 million total, their track record argues for inclusion of the model they have field tested in any NCS program. Add a zero (or two) to that budget figure, expand the geographic scope, broaden and rationalize the mission, and you have the basis of a vigorous regional element of a National Climate Service.

Conclusion

To conclude and emphasize my most important points:

- Drinking water utilities will invest hundreds of billions of dollars in the near-term in our assets—and those investments must be informed by climate change science and services delivered by an NCS;
- An NCS should have a user-centric mission that emphasizes providing actionable, accessible science to stakeholders;
- An NCS requires sufficient federal funding provided by a lead federal entity with active participation and coordination across the federal enterprise, but its most important work should take place through establishment of a multi-disciplinary, geographically distributed presence in the communities in which adaptation must take place;
- The RISA program provides a model to build upon for successful service delivery.

Thank you again for the opportunity to appear today, Mr. Chairman and Members of the Committee, and I would be happy to answer any questions you may have.

APPENDIX

CLIMATE PRODUCTS AND SERVICES

In response to specific questions from the Chairman regarding various products and services utilized by the SFPUC in our operations, the following was prepared by Dr. Bruce McGurk, Operations Manager, Hetch Hetchy Water and Power, San Francisco Public Utilities Commission.

Please discuss the climate services and products the San Francisco Public Utilities Commission utilizes; how this service is delivered; and if there is a price associated with this service. Please also discuss and provide examples of how these climate services and products affect operations and management decisions (and) is there a need for a better organization for how these services are delivered.

The SFPUC's Hetch Hetchy Water and Power division, our up-country system that provides 85 percent of total water supply, depends on real-time streamflow and reservoir elevation/storage data from USGS to monitor and operate our project and monitor other river systems around us. We pay 100 percent for 16 USGS gages (at an annual cost of $320,000) because cooperator co-funding at USGS has been cut drastically. We have re-occupied gages that USGS has cut out (Middle and South Forks Tuolumne River) because we need the data for current operations and future climate change research. The cutbacks that cause these and other high-elevation gages to be discontinued make it much more difficult to monitor runoff timing shifts and quantity, the exact issues that we need to know about to manage our water supply and detect the rate of global warming. An additional five to eight real-time stream and reservoir gages are operated in the Bay Area and funded exclusively by the SFPUC. They are used for release compliance and system monitoring.

We also use a variety of products from NOAA and the National Weather Service. We routinely use the Climate Prediction Center's six- to ten- and eight- to fourteen-day forecasts, as well as the one month and three-month forecasts. NWS forecasters provide valuable advice with the Area Forecast Discussions and Zone forecasts. The NWS California-Nevada River Forecast Center provides invaluable information with their Advanced Hydrologic Prediction Services and their daily modeling of flows into our reservoirs and others across the state. They combine historical and weather forecast data to show likely runoff from our basins for the next week to 10 days, and this is very important for reservoir operations. We cooperate with the CNRFC and supply them with climate and flow data that we collect so that they can do the best job possible with their models.

We use a wide array of other climate and snowpack information presented by the California Data Exchange Center (CDEC) and collected by cooperators all across California. We depend on snow courses, snow sensors, and other climate data that are hosted by CDEC. Data from the USDA/NRCS SNOTEL sites are also included in our runoff forecast models. We compare our runoff forecasts with NRCS and State-generated forecasts.

We have routine interaction with the NOAA Western Regional Climate Center in Reno, and they operate one of the sites that produces critical data for our runoff forecast system.

The current branches of NOAA/NWS are not focused on providing data to help with climate change inquiries. They are focused on their monitoring and short-term forecasting missions, and as a result it can be hard to find appropriate information that has long enough record, has the necessary metadata, and is searchable. An NCS that worked with NWS in regional centers and provided the data and a focus for climate change analysis would be a big improvement. This new function would address the current difficulty in partitioning the routine monitoring and forecasting from the effort to provide climate scientists and adaptation planners with the specialized products that are needed to build models using the past data and also produce data that are representative of the climate in the future.

BIOGRAPHY FOR DAVID BEHAR

David Behar career spans over twenty years in environmental policy and water utility management. David currently serves as Deputy to the Assistant General Manager, Water Enterprise, at the San Francisco Public Utilities Commission. The SFPUC is the sixth largest municipal water provider in the U.S. and manages water and power facilities and operations at Hetch Hetchy, the regional system that delivers water 160 miles to 2.5 million Bay Area residents, and water, wastewater, and stormwater facilities in San Francisco. He led development of the SFPUC-sponsored

Water Utility Climate Change Summit held in San Francisco in early 2007 and currently serves as Staff Chairman of the Water Utility Climate Alliance (WUCA). Established in early 2008, WUCA is a coalition of eight water utilities dedicated to providing leadership and collaboration on climate change issues affecting drinking water utilities by improving research, developing adaptation strategies and creating mitigation approaches to reduce greenhouse gas emissions. WUCA is chaired by SFPUC General Manager Ed Harrington and includes Denver Water, the Metropolitan Water District of Southern California, New York City Department of Environmental Protection, Portland Water Bureau, San Diego County Water Authority, Seattle Public Utilities and the Southern Nevada Water Authority. Prior to joining the SFPUC, David was an environmental policy consultant whose clients included the Natural Resources Defense Council and the Pacific Rivers Council. From 1991–97 he served as Executive Director of The Bay Institute of San Francisco, and from 1989–91 he served on the staff of U.S. Senator Alan Cranston (DCA). In November 2006 he was elected to the Board of Directors of the Marin Municipal Water District, a 200,000-customer water district just north of San Francisco in Marin County, where he lives with his two children.

Chair BAIRD. Thank you, Mr. Behar. Mr. Fleming.

STATEMENT OF MR. PAUL FLEMING, MANAGER, CLIMATE AND SUSTAINABILITY GROUP, SEATTLE PUBLIC UTILITIES

Mr. FLEMING. Good morning, Chairman Baird, Ranking Member Inglis, and Members of the Subcommittee. Thank you for this opportunity to testify before your committee today. My name is Paul Fleming, and I am the Manager of the Climate and Sustainability Group at Seattle Public Utilities.

Seattle provides reliable drinking water to 1.3 million people in the Greater Seattle area, and provides sewer, drainage, and solid waste services to Seattle residents. The City of Seattle has made addressing climate change a top priority. Our mayor, Greg Nickels, has been the leader in an effort to engage other mayors across the political spectrum on the issue of climate change, and the need to take local action.

In addition, the City's municipally owned electric utility, Seattle City Light, will likely see significant impacts to the hydropower-based operations, as climate change affects our region. They both support my testimony here today.

Seattle uses, relies on, and supports financially several monitoring and forecasting services provided by federal agencies, such as NOAA, U.S. Geological Survey, and the Natural Resources Conservation Service's, to inform our real-time decision-making and short-term planning. As Dr. Mote noted, Seattle has also engaged with NOAA's Regional Integrated Sciences and Assessment program, RISA, to assess the projected long-term impacts of climate change on our water supply, and we have used this research to develop initial adaptation options. Our operational and institutional capacity have benefited from this engagement.

As an active user of several federal services, and as a partner and collaborator with numerous federal agencies, Seattle believes there are potentially great benefits associated with the creation of a National Climate Service. We view NOAA's RISA program as a potential model, particularly given its distributed geographic structure. If it were to serve as a potential framework for a National Climate Service, the RISA model, however, would need to be strengthened and expanded along the following lines.

One, it would need to involve multiple federal agencies in the provision of services. The water sector uses the services of, inter-

acts with, and is regulated by many federal agencies. Our interaction with the federal family would be facilitated by having the relevant agencies coordinating their climate change programs and research through a National Climate Service, and by viewing it as an authoritative source of climate information.

Two, the National Climate Service should involve multiple sectors in the development and implementation of programs and services provided by the Service. The water sector is engaged on the issue of climate change. A National Climate Service should recognize this capacity, and view the water sector not just as an end user, but as a partner, as well. For example, industry research groups, such as the Water Research Foundation, should play a critical role in conducting applied research for the water sector.

Three, ensure there is consistency across the distributed structure. A National Climate Service should have a common set of goals and objectives, so that the distributed branches are coordinated and emanate from the common trunk.

Four, increase overall funding for a National Climate Service, while maintaining and expanding, if necessary, existing monitoring networks and forecasting services.

Five, build upon existing partnerships that are effective in delivering services. For example, Seattle has partnerships with the U.S. Geological Survey and the Natural Resources Conservation Service to support the ongoing operations and maintenance of streamflow and snowpack monitoring infrastructure. This infrastructure should be expanded, and a National Climate Service should build off of what currently works.

In addition, I would encourage a National Climate Service to be established in such a way that allows for an option to scale the services beyond the U.S. As the Federal Government continues to engage internationally on climate change, there is great potential for the U.S. to assist other countries in identifying the projected impacts of climate change, and enhance their adaptive capacity. In so doing, we may also address potential national security issues.

In closing, I want to reiterate a few points. Large utilities in the water sector are engaged, to varying degrees, in furthering their capacity to understand and prepare for climate change. Given the operational knowledge and institutional capacity of the water sector, a National Climate Service should involve the water sector, not just as an end-user, but as a partner.

A National Climate Service should serve as a vehicle to coordinate the climate change programs of the numerous federal agencies that are involved in this issue.

Thank you again for the opportunity to testify this morning, Mr. Chairman and Members of the Committee.

[The prepared statement of Mr. Fleming follows:]

PREPARED STATEMENT OF PAUL FLEMING

Introduction

Good morning Chairman Baird, Ranking Member Inglis and Members of the Subcommittee. Thank for this opportunity to testify before your committee today. My name is Paul Fleming, I am the Manager of the Climate and Sustainability Group at Seattle Public Utilities (SPU). SPU provides reliable drinking water to 1.3 million people in the greater Seattle area, and provides sewer, drainage and solid waste services to Seattle residents. My position at SPU is responsible for developing SPU's

climate adaptation and mitigation strategies, and establishing partnerships with other utilities and research organizations in the U.S. and abroad.

SPU, like many water utilities in the US, is an active participant in numerous water sector climate change initiatives related to the management, policy and technical challenges and research needs that arise from the projected impacts of climate change. We are one of the founding members of the Water Utility Climate Alliance (WUCA), a group of eight urban water suppliers that collectively provide drinking water services to nearly 36 million people. WUCA is currently funding two projects: one on decision support systems for the water sector and another on an assessment of climate modeling. SPU is also active in the climate change initiatives of the Association of Metropolitan Water Agencies, the American Water Works Association and the International Water Association. SPU is currently advising both the Water Research Foundation and the Water Environment Research Foundation as they develop their climate change research agendas for the drinking water and clean water sectors respectively and continue their leadership roles in supporting emerging research. We are also reaching out to utilities and researchers in an effort to glean best practices from other parts of the world. This engagement with multiple entities reflects SPU's belief in the importance of climate change for the water sector and our commitment to continually enhance our institutional capacity to prepare for the implications of climate change. This depth of engagement, understanding and commitment is common to varying degrees amongst numerous large water utilities in the U.S.

The City of Seattle has made addressing climate change a top priority. Our mayor, Greg Nickels, has been the leader in an effort to engage other mayors across the political spectrum on the issue of climate change and the need to take local actions. In addition, the City's municipally-owned electric utility, Seattle City Light, will likely see significant impacts to its hydropower-based operations as climate change affect our region. They support my testimony here today.

Today, I will highlight some of the existing federal monitoring and forecasting services Seattle relies on for water supply system operations and planning, describe how we use these services to help ensure that we meet our responsibilities and policy objectives and describe attributes that we would like to see in a National Climate Service.

Seattle's use of Federal Monitoring and Forecasting Services

Seattle's water supply is derived from two watersheds located in the Central Cascade Mountains in Washington State: the Cedar River and Tolt River Watersheds. These watersheds receive precipitation in the form of rain and snow. Seattle manages these watersheds, the Cedar and Tolt Rivers, and our mountain-based reservoirs, to achieve the following objectives:

- Water supply for people
- Instreamflows for aquatic species
- Flood management
- Dam safety
- Water quality

Given the dynamic nature of managing our water supply system, with our multiple objectives, capricious weather and the need to balance immediate and short-term issues with longer-term planning horizons, it is critical that we have access to real-time monitoring and forecasting information. Seattle relies on several federal agency monitoring and forecasting services to help inform our decision-making. These services include, but are not limited to:

- U.S. Geological Survey's (USGS) stream gages
- Natural Resources Conservation Service's (NRCS) SnoTel sites
- National Oceanic and Atmospheric Administration's (NOAA) National Weather Service's weather observations and daily and mid-range weather forecasts,
- NOAA's Climate Prediction Center's 30–90 day and multi-seasonal climate outlooks
- NOAA's Remote Sensing of Snowcover

Seattle uses these services and others for operational planning at multiple time scales, from day-to-day to several months out, to manage our rivers and reservoirs in order to meet our objectives. USGS gages are used to help us comply with our landmark Cedar River Habitat Conservation Plan and to protect salmon habitat and salmon redds on the Cedar River. The National Weather Service's general weather forecasts inform our reservoir operations and help us time releases of water. NRCS's

SnoTel sites provide us with estimates of snowpack which we can use to project how much water is embedded in the snow blanketing the hills in our watersheds. These services are our eyes and ears on the ground as well as the binoculars peering over the horizon.

These services also serve as an authoritative and credible source of information, which is critical for the type of collaborative resource management decision-making that we engage in on a regular basis.

In addition to using these services, Seattle provides financial and in-kind support for some of them. The Tolt and Cedar River Basins are extensively gauged and networked, partially as a result of a cooperative funding arrangement between SPU, Seattle City Light and USGS. In 2009, SPU will contribute roughly $125,000 towards this arrangement. We greatly appreciate this arrangement and the excellent work of the Tacoma, Washington Office of the USGS. For the NRCS's SnoTel program, we provide in-kind surveying of the land where their equipment is located. We have invested in these systems and appreciate and depend on continued federal support for them.

Another federal service we have used is NOAA's Regional Integrated Sciences and Assessment (RISA) program. In the Pacific Northwest, the RISA program is represented by the University of Washington Climate Impacts Group (UW–CIG). UW–CIG has been instrumental in helping to elevate the issue of climate change in the central Puget Sound region and Washington State. The research UW–CIG has conducted has greatly advanced the region's ability to understand how climate change is projected to affect different sectors of the region and state. Seattle benefited directly from engaging with the UW–CIG to conduct two studies within the past five years on how climate change is projected to affect the hydrology of the watersheds where we operate.

The most recent study we completed involved the creation of three climate scenarios that were based on three Global Climate Models (GCMs) coupled with two emission scenarios and down-scaled to the central Puget Sound region. The three scenarios projected decreases in our water supply ranging from six percent to twenty-one percent by 2050 due to climate change. Given this projected range of impacts, we then developed initial adaptation strategies and evaluated their effectiveness in offsetting the reductions in supply. The first strategies we've evaluated were "no-regrets" strategies: operational adjustments that are low to no-cost, enhance our operational flexibility and which could be implemented quickly. By deploying this initial portfolio of strategies we estimated we could offset the impacts of climate change in two out of the three climate scenarios.

This assessment also reinforced the role of water conservation as an essential component of our climate change strategy. Since 1984, our total water consumption has declined by 28 percent while population has grown by 26 percent. As a result, water consumption per capita is 43 percent less than it was a year ago. This has been due to the combined effects of higher water rates (and a seasonal and inclining block rate structure), the Washington State plumbing code, over two decades of aggressive conservation programs, and improved system operations. We are also committed to saving an additional fifteen million gallons a day (mgd) through conservation programs over the next 20 years. By 2030, we project that water demand will still be less than it was in 1965 even though we'll be serving 80 percent more people.

This engagement with the research community has strengthened Seattle's knowledge of the implications of climate change, stimulated our development of initial adaptation strategies and enhanced our institutional capacity. We look forward to continued interaction with UW–CIG, federal agencies and the research community as a whole in the co-production of knowledge.

A National Climate Service

It is often noted that water utilities are on the "front lines" of, or "first responders" in, the battle against climate change. While this characterization is apt, it doesn't fully capture the breadth of activities the water sector pursues in operating and managing our systems and in identifying and preparing for the impacts of climate change. To continue with the martial metaphor, we're not just on the front lines, but we're also in the war room gleaning intelligence data from original research and reconnaissance we have conducted; we're often using satellite data to determine how much resources (e.g., water) we have to utilize; we're assessing threat levels through vulnerability assessments, developing new tools to counter those threats, and building alliances to share information and resources. The broad spectrum of strategic and tactical activities that the water sector is engaged in illustrate that we take the issue of climate change seriously and that we have the capability to do a lot of work. We need, however, the support of, and continued collaboration

with, the Federal Government and welcome an integrated and user-driven National Climate Service that hastens our ability to identify and prepare for the impacts of climate change.

As an active user of several federal services and as a partner and collaborator with numerous federal programs, Seattle believes there are potentially great benefits associated with the creation of a National Climate Service. Having extensive experience with NOAA's RISA program, we view that as a potential model, particularly given its distributed geographic structure. Such a structure has the potential of establishing strong linkages between the research community and the relevant sectors in a given region and creating tailored research and services that help to address a region's needs. If it were to serve as a potential framework for a NCS, the RISA model, however, would need to be strengthened and expanded along the following lines:

- Involve multiple federal agencies in the provision of services. The water sector uses the services of, interacts with and is regulated by several agencies. Having multiple agencies involved in the NCS and viewing it as an authoritative source of climate information would facilitate our interactions with these agencies.
- Involve multiple sectors in the development and implementation of programs and services provided by the NCS. As I have noted before, the water sector is engaged on the issue of climate change and is enhancing its capacity to understand and prepare for the impacts. The NCS should recognize this capacity and view the water sector not just as an end-user but as a collaborator as well. This is particularly salient with respect to vulnerability assessments, where a utility's tacit knowledge of its system operations can "ground truth" the assessment and identify and evaluate the effectiveness of operational adjustments. Such an emphasis could also help to complement the current university context for RISA program delivery.
- Ensure there is consistency across the distributed structure by establishing a common set of goals, objectives, and tenets across the country so that the NCS is responsive to the water sector's need for "actionable science" and that the distributed "branches" of the NCS are well coordinated.
- Increase overall funding for an NCS while maintaining and expanding, if necessary, existing monitoring networks and forecasting services. These services are essential for operations and planning today and will be even more critical in the future.
- Build upon existing partnerships that are effective in delivering services. As noted previously Seattle has established relationships with USGS and NRCS to support the ongoing operations and maintenance of streamflow and snowpack monitoring infrastructure.
- Establish a structure that allows for an option to scale the services beyond the U.S. As the Federal Government continues to engage internationally on climate change, there is great potential for the U.S. to assist other countries in enhancing their adaptive capacity as well as learning from them while also addressing potential national security issues. Through appropriate agreements or perhaps as part of foreign aid programs, the National Climate Service potentially could provide essential monitoring services and research for areas of the world that don't have access to such information.

Conclusion

In closing, I want to reiterate a few points:

- Large utilities in the water sector are engaged to varying degrees in furthering our understanding of the implications of climate change and in preparing for the challenges it creates;
- We welcome additional federal collaboration that builds off of and expands existing monitoring and forecasting services and collaborative partnerships;
- Given the operational knowledge and institutional capacity of the water sector, a National Climate Service should be based on a geographically distributed but nationally coordinated structure that involves and complements the water sector's tacit knowledge and experience.

Thank you again for the opportunity to testify this morning Mr. Chairman and Members of the Committee.

BIOGRAPHY FOR PAUL FLEMING

Paul Fleming is the Manager of the Climate and Sustainability Group for the Seattle Public Utilities (SPU). SPU provides a reliable drinking water supply to 1.3 million people in the Seattle metropolitan area and provides essential sewer, drainage and solid waste services to City of Seattle customers. Paul leads SPU's climate change initiatives and is responsible for developing and directing SPU's climate adaptation and mitigation strategies and research agenda as well as establishing collaborative partnerships with other utilities and research organizations in the U.S. and abroad. Paul also supervises SPU's green building program and is involved in SPU's sustainable stormwater infrastructure initiatives.

Paul is an active participant in several national and international efforts focused on water and climate change. He is active in the Water Utility Climate Alliance, an alliance of eight U.S. urban water suppliers focused on adaptation, GHG mitigation and climate research, where he chairs the Science and Research Committee. He serves on the Water Research Foundation's Climate Change Strategic Initiative Expert Panel, where advises the Foundation on the development of a climate change research agenda for the drinking water sector. He is also advising the Water Environment Research Foundation on their development of a climate change research agenda for the drainage and wastewater sector. Paul develops and leads SPU's international collaborative efforts, including work with Dutch researchers on urban drainage climate adaptation. He is also participating in a U.S. State Department-funded project that is examining security, energy, water and climate change issues in Central Asia.

Paul has been an invited speaker on climate change and water at water industry conferences and workshops in Washington State, Amsterdam, Atlanta, Baltimore, Colorado, Edinburgh, Toronto and Tokyo. Prior to his current position Paul managed SPU's State legislative agenda and worked on State and regional water supply and environmental policy issues.

Paul is a board member of *Worldchanging.com,* which is a media organization that covers tools, models and ideas for creating a better future. He is also a delegate to the U.S.–Japan Leadership Program. Paul has a BA in Economics from Duke University and an MBA from the University of Washington and lives in Seattle with his wife and daughter.

Chair BAIRD. Thank you, Mr. Fleming. Dr. Doesken.

STATEMENT OF DR. NOLAN J. DOESKEN, PRESIDENT, AMERICAN ASSOCIATION OF STATE CLIMATOLOGISTS; COLORADO STATE CLIMATOLOGIST, DEPARTMENT OF ATMOSPHERIC SCIENCE, COLORADO STATE UNIVERSITY

Dr. DOESKEN. I am used to extemporaneous stuff, so wish me luck.

Mr. Chairman, Ranking Member Inglis, Committee Members. I appreciate this opportunity to represent a State perspective on climate services. I am the State Climatologist for Colorado, the current President of the American Association of State Climatologists, and here is a little description of what we do.

We are experts on the climate of our own states, whether it is just basic temperature and precipitation patterns, seasonality, geographic variations, year to year variations, which are a really big deal, drought and other extremes, which are a really big deal, and historic trends, which are very interesting.

Perhaps more importantly, we see how the climate affects the citizens of our states, their lives and their livelihoods. We rely on data, quality, representative observations of our climate system, whether it is temperature networks, humidity, wind, precipitation, or very important, solar energy, all of the elements of our climate system. And our ability to provide useful information to our states really relies on the presence of quality data.

Whenever I travel, I see climate services in action. The infrastructure that we drive on, our bridges, our culverts, our energy

distribution systems, our buildings consuming energy to keep comfortable inside, regardless of the variations outside, and how we utilize what we know about our climate to better adapt our infrastructure.

We have traditionally relied on federal sources for the data that we use in what we do. National Weather Service Cooperative Observer Network, very important. Airport weather observations through many decades. U.S. Geological Survey streamflow data, NRCS, which we have heard of here today. Soil moisture measurements, mountain snowpack data, streamflow predictions. We are long-time users of NOAA data resources in so many ways.

We basically believe the climate monitoring activities are predominantly a federal responsibility, but more so, we keep seeing our fellow states doing more data collection on their own to address their own, State-specific needs. At least half of us, as State climatologists, are involved in some way in our own data collection systems. Often, for agricultural purposes; also for energy, water resources, et cetera.

Let me talk briefly about collaborations, because if you knew what our State budgets were, and you probably do, we can't function well without collaborations, rich collaborations with federal partners. Many of us work closely with our Regional Climate Centers. We know them as friends. These groups have helped us stream out data access and management, so we can focus on interpretation of information, and the delivery of that information.

A few of us have the benefit of working with RISAs. I am one of them, in Colorado. Not all states have RISAs. Many of our, my fellow State climatologists, have no experience working with RISAs, just because they are limited in geographic extent. Unlike RISAs, who get to focus on specific sectors and decision-makers, we get to work with the whole gamut, anywhere from State government down to small business and individuals.

Private companies are pretty good friends with State climatologists. We provide information that really helps them make their business decisions, and we are not viewed as competition.

National Weather Service, long partners, data collection, and more recently, in data services. And our organizational structure that facilitates working with the Federal Government is our association, the American Association of State Climatologists, just as a vehicle for two way communications. It is a little more efficient.

In summary, we are local experts. We work at the grassroots level. We are an essential branch of climate services as they are occurring today. We track the pulse of our climate at the local level, and we do so on very, with very few resources, in so many ways. We are trusted advisors to State and local government, business, individuals, and communicators of information to our local media. We are flexible, and we are responsive.

We are largely educators; 80 percent of us are at public universities. Many of us teach students, mentor grad students, as well as aid in decision-makers. More than 60 percent of us are at land grant universities, and utilize the infrastructure and wisdom of our traditional system of extension to reach broad audiences.

So, we favor the concept of a National Climate Service. We are ready to help.

Thank you.
[The prepared statement of Dr. Doesken follows:]

PREPARED STATEMENT OF NOLAN J. DOESKEN

Thank you very much for this opportunity to share a State perspective on climate services.

Background

Prior to 1973, each state had a State climatologist as a part of a long-standing climate program within the Department of Commerce, U.S. Weather Bureau. When that program was abolished in the early 1970s, states—as they were able over a period of years—established their own offices to carry on the functions of State-specific climate monitoring, research, education and service. NOAA's National Climatic Data Center (NCDC) was an early partner in fostering State-based climate activities. NOAA data, particularly temperature and precipitation data from the National Weather Service Cooperative Observer Network and more detailed Surface Airways observations, were the primary data sources at that time for almost all U.S. ground-based climate monitoring, research and service. NCDC still remains a strong partner supporting State efforts, facilitating access to data, and enlisting our expertise in a variety of ways.

The American Association of State Climatologists (AASC) was established in the mid 1970s to professionally link the efforts of these emerging State programs, and to offer a forum for federal partners to more easily communicate and work with states on climate-related issues. AASC is an effective organization for communicating federal-level climate services, through State Climatologists, to the citizens and local stakeholders that we serve, within our states. It has also been an appropriate forum to communicate State-level data and information needs back to federal agencies. While there is so much climate diversity across our country, and the challenges faced by individual states vary greatly, we share many common interests and concerns that are best addressed together. For example, access to reliable long-term climate data, best practices in data analysis, applied research strategies, means of identifying and assessing State and local climate variability and change, effective means of outreach, and means of engaging stakeholders and assessing the impact of our efforts.

Recognizing the important role of State Climatologists, the *National Climate Program Act of 1978* included language that requested federal funding for State Climate Offices to improve the consistent delivery of critical climate information to the citizens of the United States. Funds for individual State activities were never appropriated then. Still, State climate offices independently developed. The *National Climate Program Act of 1978* did not directly help State climate service efforts, but it did lead to the eventual formation of Regional Climate Centers (RCCs) which have been excellent partners and assets to State climate services ever since.

Currently 48 states have State Climate Offices. Some are housed within State agencies, but most are affiliated with State universities. The majority, such as my host institution, are at Land Grant universities. Most State Climatologists are actively involved in research and teaching—collectively mentoring hundreds of future scientists and educators each year. Many of us are well connected or directly a part of our State Extension programs adding further to our outreach effectiveness.

Activities of State Climate Offices

State Climatologists (SCs) are experts on the climate of our respective states—seasonal cycles, geographic variations and year-to-year variability. We are familiar with the climate data resources of our states over the period of instrumental record—typically back to the 1880s. Some of us have expertise in paleoclimatology which helps provide longer perspectives about climate variability. Nearly all SCs have additional areas of expertise ranging from observation systems, agriculture, and remote sensing, to hydrology, climate modeling and climate change. We enjoy helping others find the data and information they need to address their challenges and opportunities. We often operate on a "grass roots" level, providing personalized and localized climate information to a wide range of businesses, individuals, and organizations. We don't often have the luxury of focusing our efforts on the needs and climate-affected decisions of specific user groups. Instead, we work with diverse groups—State and local government, utilities, large and small businesses, engineers, architects, builders, consultants, attorneys, researchers, educators, media and many others—and we do so with a local understanding of the climate and an appreciation for the needs and applications of the customers. Rather than just providing re-

quested data, it is customary to ask "How will you be using this information?" That simple question so often results in better service, greater trust, frequent opportunities for applied research, and better information about the types of data, models and other decision-making tools, monitoring systems, forecasts and projections needed to answer important questions.

A typical day in the life of a State Climatologist may go something like this. We may brief State agencies in the morning, do a media interview at lunch, teach a class and answer a variety of climate information requests during the afternoon, and then give an invited talk to a community organization during the evening. We are typically passionate about our work and love sharing information with others. Our products, services and approach to outreach vary somewhat from state to state, and are customized to meet specific local needs. Products typically include addressing weekly or monthly climate monitoring and reporting (to State and federal agencies, media, etc.), drought and water supply monitoring, agricultural decision support, historic climate trend analysis, information sources and tools for engineering, architecture, design and related consultants, and consultation to emergency management and law enforcement officials and to the legal profession. Some State offices have actively provided climate data and information supporting renewable energy planning for over 30 years.

Here are a few examples of specific State activities, showing the breadth of our services.

http://www.nc-climate.ncsu.edu/

http://www.ndsu.nodak.edu/ndsu/ndsco/

http://climate.rutgers.edu/stateclim/

The AASC website provides quick-click access to all State Climate Office web sites
http://www.stateclimate.org/

State Climate Offices are both users of existing federal climate data sources and providers of unique local data. State climate offices continue to rely on the National Weather Service Cooperative Network data because it is the best source for high-quality nationwide temperature and precipitation data, the only source for nationwide snowfall data, and the only source of relatively consistent century-long nationwide data on the scale of individual counties. But we are interested in any well documented, verifiable data source to help us track specific elements of the climate within our states. We are currently partnering with NOAA to improve State-level data accessibility and information products for the new modernized Historical Climate Network (HCN–M) and the recently deployed Climate Reference Network (CRN).

Driven by ever-growing demands for instantaneous weather data at a high-spatial density, many SCOs manage and maintain specialized observing networks. Best known is the Oklahoma Mesonet *http://climate.ok.gov/mesonet/* But many other State climate offices are also involved in aggressive data collection efforts to meet a variety of decision support functions. Even low tech approaches like the volunteer "Community Collaborative Rain, Hail and Snow network" *http://www.cocorahs.org* are helping gather important data while helping educate the general public about climate. The potential exists to integrate public and private data sources to achieve a national "mesonet" to serve both instantaneous weather and longer-term climate service and research needs.

Real time weather data for forecasting and operations have great value but are not always suitable for climate analysis and research. The exact location of weather stations and how well they are maintained make a big difference to climatologists. Therefore, State Climate Offices give much attention to data quality and the development of quality control procedures and tools. We inform NOAA regarding our standards and expectations for climate data and information products. We also work with other federal agencies involved in climate monitoring and research. Stream flow measurements by the USGS, mountain snow accumulation, snow water content and soil moisture measured by the USDA–Natural Resources Conservation Service, and fire weather conditions monitored by the U.S. Forest Service and Bureau of Land Management all feed in to effective climate monitoring at the State and local level.

State Climatologists receive frequent requests for statewide or more localized information and interpretation of seasonal climate forecasts and climate change projections and potential impacts. Because of the huge scale and magnitude of these efforts, most states rely on the National Weather Service Climate Prediction Center for seasonal forecast information. For climate change projections and impacts, we typically turn to the resources of the Intergovernmental Panel on Climate Change (IPCC) and the Climate Change Science Program (CCSP) as well as other State and

regional assessments by public and private entities. We then communicate this information to our more localized audiences adding our knowledge and local perspective.

State Climate Office relationships with existing NOAA climate service programs

As stated earlier, the AASC has worked with NOAA's National Climatic Data Center from our very beginning and appreciate the support that has been provided to our members. We also enjoy close working relationships with Regional Climate Centers. Some State Climate Offices are co-located with RCCs. Some RCC staff have previously worked in State Climate Office settings and understand our needs. RCCs have helped State Climate Offices by reducing the need for each of our states to maintain our own independent climate databases for NOAA and other agency climate data resources. The wide variety of information available from the Western Regional Climate Center web site is a good example. *http://www.wrcc.dri.edu/*

Our concerns regarding access to climate data and analysis are usually heard and often addressed. For example, the RCCs are currently developing a climate data access system specifically for State Climate Office needs based directly on specifications developed by our organization.

National Weather Service climate service activities have, in recent years, become much more active and visible ranging from drought monitoring, to dissemination of seasonal forecasts to timely web-accessible local climate information. Because of their public visibility and accessibility, the NWS is often the first stop on first-time users' quests for climate information. Traditionally, the NWS major field-level role in climate service was climate data collection including the operation of their nationwide Cooperative Observer Network and airport weather data collection. This has been essential for basic climate monitoring and research. With data analysis support provided through the RCCs, NWS Forecast Offices have greatly improved their own local climate service potential in recent years. This has beneficially taken some of the load off SCOs in terms of routine individual climate information requests.

AASC collaboration with Regional Integrated Sciences and Assessment teams (RISA) is a work in progress but with much potential for further enhancement. Up to this point, most states have not had RISA teams with which to partner. RISAs have benefited from the ability to focus on particular environmental applications and selected decision-makers. This is in marked contrast to State Climatologists who must address the diverse needs of all stakeholders and citizens within their states. Nevertheless, where RISAs have been active for several years, including where I work in Colorado, we are finding many and effective ways to partner to improve climate services, including customized climate education, and focused research and data product development needed to address the questions of specific decision-makers. A 2008 report sponsored by the Colorado Water Conservation Board, *"Climate Change in Colorado—A Synthesis to Support Water Resources Management and Adaptation,"* is an example example of RISA-enabled State partnerships.

The presence and activities of the National Climate Program Office (NCPO), while well known at the national level, are not routinely evident at the individual State level. The NCPO has reached out to the AASC and invited our participation in several national-level planning and evaluation meetings (e.g., climate services; drought). We are represented on NOAA's Climate Working Group, their lead external advisory body, which evaluates and recommends future directions for all NOAA observing, research and outreach endeavors related to the climate system. Indirectly, we also benefit from the NCPO's support of RISAs and their sponsorship of other applied research endeavors.

The National Integrated Drought Information System (NIDIS) is a relatively new program but one that may have a large impact on State Climate Office activities. Drought-related efforts at the State level are often the most time consuming and important of all of our multi-faceted endeavors. AASC collaborations with NIDIS may have substantial mutual benefits. Here in Colorado, NIDIS is offering our office a lead role in shaping a portion of the Upper Colorado River Basin NIDIS pilot project with a focus on the drought early warning needs of several specific user groups.

The American Association of State Climatologists and the National Climate Service

In 2008, the AASC prepared a statement expressing our interest and identifying our potential role in a developing and evolving National Climate Service. *http://www.stateclimate.org/publications/*

Our Association looks favorably on the establishment of the National Climate Service. A well-organized National Climate Service has considerable potential to focus federal resources on global, national, State and local climate challenges. We see NOAA as a logical agency to lead this effort and we look forward to doing our part. We have much to offer and much to gain. Because we work most effectively on the State and local level, and have a finger on the pulse of what many decision-makers require, the AASC can add a credible local presence and voice to complete an effective National Climate Service. We are counting on NOAA, and other federal partners needed to construct an effective service, to work well together and to recognize the essential and foundational nature of systematic climate monitoring—maintaining and enhancing climate observing networks that simultaneously meet many needs (energy, water, agriculture, transportation, commerce, public safety, etc.).

A concluding story

In conclusion, I would like to tell a short personal story. Over 20 years ago when "Global Warming" was first appearing regularly in the national press, I was invited to speak to a meeting of the "Colorado Young Farmers" organization. These farmers were mostly in their 40s at that time and well educated. They politely listened to the presentation where we showed upward trends in greenhouse gases and discussed the possible implications and some early climate model projections of warming. Then we showed graphs of 100 years of observed data over eastern Colorado. As dryland farmers on the Great Plains, they were intimately familiar with climate variability and its impacts on their lives and livelihoods. After the formal presentation ended and as we sipped hot coffee, one of the leaders of the organization came up to me (and I will never forget this). "I guess we should take climate change seriously. When I look back at my grandpa and how he farmed I think we can change—we will change. We've already changed our farming practices so much. But this darn year-to-year variability . . . that's what kills us. We appreciate what you scientists are learning about climate change, but if you can do anything to help us deal with the big changes we see from year to year, we'll be very grateful."

With that in mind, we (the AASC) appeal to you to seriously consider the full range of potential benefits of a National Climate Service across a variety of time scales. With growing concern regarding climate variability and change in a vulnerable society, the needs for both generalized and customized climate data and information will only continue to grow and become more acute. Take the necessary time to develop the appropriate leadership structure that can incorporate the extensive expertise and service capabilities of other federal agencies and make full use of expertise and flexibility of State and university partners. Together, we can accomplish much.

Thank you very much for this opportunity to share my views and those of many of my colleagues.

BIOGRAPHY FOR NOLAN J. DOESKEN

Nolan Doesken grew up in rural central Illinois with an early fascination with weather and climate that has stuck with him his entire life. He attended the University of Michigan receiving a Bachelors Degree in Meteorology and Oceanography in 1974. He returned to Illinois for graduate work at the University of Illinois. There he conducted climate research at the Illinois State Water Survey while completing a MS in Atmospheric Science in 1976. Nolan moved to Colorado in 1977 to become Assistant State Climatologist at Colorado State University. Over the past 32 years he has been involved in a wide variety of climate research and educational activities with a special focus on drought, precipitation measurement and analysis, and the effects of climate on agricultural and natural resources. He has worked with the National Weather Service on several projects evaluating climate data from new observing systems. Mr. Doesken is currently assisting the National Integrated Drought Information System (NIDIS) in the Upper Colorado River Basin pilot project. He has published many climate-related articles and reports including a popular book on snow: *"The Snow Booklet : Guide to the Science, Climatology and Measurement of Snow in the United States"* (1997). Nolan is just the fourth Director of the historic Fort Collins Weather Station with a record of continuous climate monitoring dating back over 120 years. He also manages the Colorado Agricultural Meteorological Network (CoAgMet).

Nolan became Colorado State Climatologist in 2006. He is a long-time member of the American Association of State Climatologists (AASC) and became President of that organization in 2008. Nolan was honored as a "NOAA Environmental Hero" in 2007 for his work in starting a nationwide volunteer program (CoCoRaHS—Commu-

nity Collaborative Rain, Hail and Snow network) which provides climate education opportunities for the public while also producing an exceptional research-quality data set for climate monitoring and to aid weather forecasters.

Nolan and his wife, Kathy, have a small farm near Fort Collins, Colorado. Nolan serves on the Board of Directors of an irrigation company there.

DISCUSSION

Chair BAIRD. Thank you, Dr. Doesken, and thanks to all the panel, again, for your insightful testimony today, but also, your service.

MORE ON STRUCTURING A NATIONAL CLIMATE SERVICE

So, I am trying to envision the organizational chart in my head, which is maybe some of what we have been dealing with on the panel. And it is evident to me that you represent users, but also producers of information. It is clearly a two way system, where you can say our experiential data feeds back into the loop and vice versa.

Does it make sense to come up with, if you had a National Climate entity, Service, does it make sense that you would look at some of the various agencies that you have described already, like NRCS, like USGS, like the Weather Service, like the RISAs, and others, doubtless, and say okay, so the National Climate Service, maybe those entities continue pretty much as they are, but the National Climate Service is the coordinating entity that brings their data together, and to some extent, the sub-agencies maybe have people with dual assignments or dedicated missions, so you know, they answer, sort of both chains.

What about that idea? Bad idea, good idea, does it make sense, what is already being done, but there is the lack of a national coordination? What are your thoughts on that?

Mr. BEHAR. I will start. I think from a stakeholder perspective, having that kind of one stop shopping approach that leverages the data and information, leverages the expertise that exists, and leverages the regulatory and operational relationships that we already have with entities like GS and Bureau of Reclamation, if we are in reclamation basin, is really important.

It really will help to translate the climate change challenges to the user level. We need, ideally, a single or a few places that we know we can go to get the data, the analysis, the research assistance, and all the other inputs that go into, in the case of the water utility, in most cases, our systems operations models, so that we can then think about what it is we face, in terms of our water supply.

Then, down the chain, we also probably could use some help from social scientists and others who are evaluating decision support methods that can be used in an atmosphere of uncertainty, which we know we'll obtain for many, many, many years in the future, no matter how much more money we put into the climate models, which we do think we should put more money into the climate models.

And so from, you know, from end to end, as simple a structure as possible will be beneficial. It is very hard for users to really un-

derstand all of the different entities that are out there, and streamlining that would be very beneficial.

Chair BAIRD. Mr. Fleming.

Mr. FLEMING. I would add that you seem to describe almost a matrix management approach, which I don't know if the Federal Government does that very well. I don't know if anyone does that very well, but I think fundamentally maintaining——

Chair BAIRD. We won't get into credit default swaps, and we will be all right.

Mr. FLEMING. Ensuring that systems that are working now are not disrupted. So, I think, to varying degrees, you know, we are able to access pretty good information, really good information from USGS and NRCS, at least in Seattle, and I think Dr. Strobel would probably echo that, that that is the case across the Northwest and other parts of the country.

So, National Climate Service should not disrupt those services that are working really well, but I believe there are information gaps that a National Climate Service could step into. So, it seems to me that you would want to have some service that does, provides some integrated function to it, and that doesn't replicate what is working now. And that is, we would definitely welcome coming back to you per your invitation to the previous panel, because I think you have an organizational challenge and opportunity ahead of you in crafting this bill.

Chair BAIRD. Dr. Doesken.

Dr. DOESKEN. Well, we feel very much like, I guess you would call us middlemen. We need a national perspective, a national modeling activities, national prediction skills that we will never have the capacity at the State level to do.

And some customers want to be able to go right to that level. Other customers much prefer coming to a local level or a regional level. So, it seems like there is very good reasons to have a three tiered system, where users can enter at the level that they work. Exactly how all the pieces come together, I am not yet totally clear on, either, but leveraging the skills and capabilities and activities that are already involved, you got to start there.

Chair BAIRD. And the notion we have heard, a great deal of today, also is that if you were, let us say you are an industry, or you are newly appointed to run some municipality, where do you go? It takes a while just to get up to steam, and there are places where you would like to go, and they don't exist yet. We don't have the datasets or, but it just takes you a while to figure out who you have got to talk to.

INTERAGENCY COORDINATION

And in your experience, is the coordination across the various agencies sufficient, or do you find that well, I have to go to these folks for this, and then these folks for this, and get a little bit here, and then I piece it together with more or less degree of accuracy and certitude. How does that work?

Dr. STROBEL. Well, I guess I could just say that it is getting better. The fact, with the availability of the Internet, and the way that we can link on to other people's information and share that information, and the accessibility that folks have to access that informa-

tion, not always just through our sites, but through other people's sites, and linking into it, has really greatly improved the collaboration and sharing of information, and the accessibility of that information.

So, is it perfect? No. But is it getting better? Yes. I see very positive things happening with that.

Chair BAIRD. Do you feel like a climate service entity within the, at the federal level would help facilitate that, or create new problems?

Dr. STROBEL. Our Department hasn't come out with a statement on this yet. I will just say that there are always benefits to more collaboration and more accessibility to the information. I mean, the more we get it out to the users, the better it benefits everybody.

Chair BAIRD. Mr. Fleming, and then, I will recognize——

Mr. FLEMING. Seattle relies on the Internet to a large degree to get some of this data, particularly for the operational decisions, where we are looking at weather forecasts, to understand whether we need to make releases to provide flood management, or to ensure that we don't scour salmon rights in the rivers that we manage.

I will also add that, you know, we have benefited immensely from having a RISA program in Seattle. The University of Washington Climate Impacts Group is a couple miles north of our offices, and we have been able to rely on them and work with them to enhance our understanding of what the implications of climate change mean for our water supply.

So, to some degree, we definitely see the benefits of a National Climate Service, but we are operating from the position of having tremendous resources in our backyard.

Chair BAIRD. Okay. The final thing, I would just comment before I yield to Mr. Inglis is that if you look historically at some of the great trends and changes in human history, the big dislocations, conflicts, it is so often climate-related, and that ties to demographics. And one of the things that I struggle with is, census data tells us we are looking at 139 million more people in this country in the next 40 years. Very rarely do we make informed decisions about where people can live. We don't say gee, you know, if you all move to the desert, you might just have a water problem. And people tend to move there, and then expect somebody else to fix it, and somewhere, we have got to integrate the kind of data that you folks are experts in, with those kind of decisions, and we are miserable at doing that, actually.

Mr. Inglis.

STATE CLIMATE OFFICES

Mr. INGLIS. Thank you, Mr. Chairman. And Dr. Doesken, how are State climate offices typically funded? Is that by State appropriations, or are you getting federal money?

Dr. DOESKEN. It is highly variable. And in some cases, it is on a State line item budget, but in many cases, it is within university settings. Only about six of us, I think, are in State government, of which South Carolina is one of those examples.

So, we are all fighting our own battles in various ways, but again, we are typically affiliated with universities, and universities

have found us to be great assets to the research efforts and the educational efforts that go on there. So, it makes some sense.

Mr. INGLIS. So, what we are talking about here, in creating a new office that would consolidate some of these things, or I am not sure consolidate is the right word, create new information. Is it, what do you see as the future of climate offices, the State climate offices, in that?

Dr. DOESKEN. Well, trying to find the right place for us is, without asking for way more State or federal money, is a real challenge. We would like to see the service that we are providing funded to the level that our states need, and whether that is through State support, or whether it is through federal support, we are open either way.

But we have a lot of flexibility when we are not a line of a federal agency. It gives us a lot more nimbleness on the local level, so we like to stay independent as much as we can, but would like to see additional support come to us, so we have more uniformity in what we are able to do nationally.

Mr. INGLIS. Do you, do climate offices, State climate offices ever charge for their data, or how does that work? Do you get fees from somebody?

Dr. DOESKEN. We charge in a way that may vary from state to state. We definitely collect revenue when we are able to, to help offset some of our local expenses, and we work, utilizing graduate students and undergraduate students helping in our services, which is great training for them for the future, as well.

Mr. INGLIS. And you are the folks that set drought levels and things like that. Is that right? I mean, in South Carolina, for example, the State Climate Office there declares when we are, what level of drought, and that sort of thing.

Dr. DOESKEN. We participate greatly in that process. State climatologists probably spend more time dealing with drought-related issues than most any of the other factors that we get to work with.

Mr. INGLIS. And I guess I am maybe asking a question you don't know, because it is South Carolina, but does that, is that a call by that office, or do they work with somebody else to make the call about restrictions, for example, on water usage?

Dr. DOESKEN. It is a function of State drought response plans, how they have been written. Usually, we are advisors to the process. In only some states does the State climatologist actually make that call.

Mr. INGLIS. That is helpful. So, do you feel that the State climate office's standards and expectations for climate data are met by NOAA and other federal entities involved in producing those, that data?

Dr. DOESKEN. We think they are doing a pretty good job monitoring for federal response, and a regional response. For State-based responses, higher resolution information, both in time and in space, are often required, and the measurement of variables that federal programs haven't always monitored. For example, soil moisture, evapotranspiration, things that help us with the water balance a little bit more. That is why a lot of states have gotten into data collection, to fill in those gaps.

MITIGATING A DUPLICATION OF SERVICES

Mr. INGLIS. So, that is all very helpful. I think the thing that I might ask, just a final question. Has anybody got any additional thoughts about how to make sure that we don't create a duplicative kind of situation here in any, I mean, it has been sort of the common thread of questions emanating up here. I don't know if anybody has any further observations about that.

Mr. BEHAR. That is one of the tough questions, and we want to neither duplicate what is out there, nor create or institutionalize a dispersed structure at the climate level, as distinguished from the weather or the monitoring or data level, where obviously, we have got dispersed data sources, and need to collect those, and they are collected well, by GS, although we pay for our GS gauges now in San Francisco, because they have been discontinued by GS. And National Climate Data Center, and other places where that data exists.

In terms of the policy-making, the decision-making, the climate, decadal scale information that we are starting to think about needing to plan around, as are many stakeholder entities, the challenge is to exactly do what you posed as the challenge, which is to have as much of a centralized, but at the regional level, place for stakeholders, by the way, of varying sophistication, to go to.

It is worth noting that Seattle Public Utilities is probably at one end of the sophistication scale, at the high end, in terms of tracking this information. And there are many others who are really struggling with where to get the climate information, and how to think about it, as I think Dr. Barron alluded to as well.

And we really need to meet all of those needs, across the spectrum, and provide, as much as possible, the kind of research institution and planning assistance that Seattle has in its backyard with the SIG program that not everybody has.

That is starting to happen. We are starting to learn from examples like the RISA model, which is not duplicating what is going on anywhere else, in our view, and that is obviously one of the key questions in forming an NCS that is successful.

Mr. INGLIS. Well, I would like to add this, Mr. Chairman. You know, it is interesting that last night, we were having our dinner conversation at our house, about Wikipedia, and whether our girls should cite it, you know, and I think that they are more accurate. Isn't there some story about how they are more accurate than Encyclopaedia Britannica or something, fewer mistakes or something. And it really does show the change that information technology has brought, and the way the government has to figure out a way to harness the abilities we have now, because it used to be that you had this office doing this, and that one doing that, and this other one doing that, and they were all funded different ways, and they all had their jobs, and they didn't step on each other's toes. It doesn't deliver what people need, and what people expect, and it is a good expectation, that they get from private vendors, is you can go to the website, and you can drill down to exactly what you want.

And so, you know, get down to my farm, tell me what is the rainfall at my farm. It is really what we in government have to figure

out how to deliver, if we are going to remain relevant, and make, put it another way, deliver the kind of quality services that people expect, and that they are paying for. So, it really is, it is a big challenge here, is to figure out how to get this delivered in the most cost effective, powerful way.

It is very important work, and we thank you.

Chair BAIRD. Fascinating line of questions, as always, Mr. Inglis. As you thought, mentioned that, I was thinking one of the questions, really, is so what does it look like ten years from now? I mean, the sort of, just as we are talking about predicting climate, let us predict the organizational structure, and what does it look like ten years from now?

And, you know, is it an integrated body that creates the Google Earth, that we can scan out, so I could zoom in on a computerized image of any area of our country, and ultimately, maybe, the planet, and then, time project that out on a host of variables, whether it is water supply, temperature, moisture, ground moisture, vegetation cover.

Now, I am guessing that somewhere, that may happen, and it would be incredibly convenient, and maybe with some depth of confidence parameters around that, but how we get there is really sort of the question, and I think you are onto something there, in terms of what will that look like.

Any final comments, we are about to conclude, but I can see Dr. Doesken has got something he wants to say.

Dr. DOESKEN. But even if you are there, and I can envision that, too, because we are so close to that in many ways, still, converting that information to appropriate and wise decisions is a whole other ballgame, and we see that all the time, where people say I am smothered with data. This is fantastic. What do I do with it?

Chair BAIRD. Yeah. Yeah.

Dr. DOESKEN. And that is where a service provides that, as well.

Chair BAIRD. Mr. Fleming.

Mr. FLEMING. Just to add to that. I think that issue of what to do with the information is one where it needs to rely, or reside with the local jurisdiction responsible for making those decisions.

So, in the case of Seattle, we certainly look for and look towards having access to that type of information, but the tacit knowledge that we have, for instance, of our water supply system, is critical for making decisions, long-term decisions about what is the best course of action for that system. So, I just wanted to kind of echo that, at least in our situation, having local involvement in the development of adaptation options and decision-making is essential.

Chair BAIRD. Great. I thank our panelists, and we will just conclude with the observation I made for the prior panelists. If there are things, thoughts or ideas or suggestions that have been stimulated by this interaction, or issues that you feel we could use some further insights into, please feel free to, and ask to provide that information.

As is customary, the record will stay open for two weeks for additional comments from Members. We are grateful for the Committee's, or the panelists' participation, and with that, this hearing stands adjourned.

Thank you very much.

[Whereupon, at 12:27 p.m., the Subcommittee was adjourned.]

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