

A VISION FOR CLIMATE SERVICES IN NOAA



This report was drafted by a select team of NOAA scientists and related experts from across the Agency. The team unanimously presents these goals and principles for consideration by NOAA along with other inputs to the development of its overall climate services strategy.





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PREFACE

NOAA's climate services are now being challenged to provide a rapidly expanding set of requests for better and more comprehensive information to help our nation develop climate resilient infrastructure, communities, and natural and managed ecosystem services. The challenge is to provide credible, authoritative, and useful information as the scientific basis for decision making in the face of a changing and varying climate. NOAA is fortunate in that it can build upon its broad range of capabilities and integrate across its organization to meet this challenge. It is clear however that NOAA climate services cannot possibly meet the challenges without close ties to a larger enterprise that will require innovative partnerships with government agencies, other institutions, and the private sector.

Beginning as early as 1978, with the passage of the National Climate Program Act, there have been on-again, off-again discussions about climate services and a National Climate Service. Over the past year NOAA and its partners have taken numerous steps to further advance climate service to the nation. In December of 2008 NOAA completed a plan outlining the motivation and the benefits and challenges of several potential organizational options for climate services within NOAA. In March of 2009 NOAA's Science Advisory Board received a report from its Climate Working Group. The Climate Working Group was asked to evaluate how best a National Climate Service Enterprise might function and the appropriate role of NOAA in such an enterprise. They evaluated a number of options and the pros and cons of each option. In the same month, the National Research Council released a report sponsored by NOAA and the EPA on climate services decision support and concluded that if a national climate service is created, it should be part of a decision support services and be closely linked to a research element. Yet another National Research Council Report of particular relevance to NOAA climate services was also released in March of 2009. This report addressed a restructuring of federal climate research to meet the challenges of climate change.

Armed with this rich background of material, a NOAA team of highly esteemed climate scientists and related experts was tasked to develop a set of goals and principles for NOAA climate services. The team was led by Drs. Susan Solomon and Randall Dole. The composition of the team was selected based on one or more of the following criteria and balance across the criteria:

1. A demonstrated record of national and international leadership and accomplishments in climate-related science
2. Breadth of understanding the scope of climate-related impacts and vulnerabilities of particular relevance to NOAA
3. Management responsibility for climate-related operations and research
4. Diversity of perspectives across the agency.

The importance of this document cannot be overemphasized. As NOAA embarks on the development of its climate services it must be guided by a set of goals and principles. Adherence to an agreed-upon set of goals and principles will enable NOAA to develop an effective organizational structure and related implementation plans for its climate services.

I am pleased to report that the team of experts has unanimously agreed to a set of goals and principles that can now be used to guide the development and operation of NOAA climate services.



Thomas R. Karl,
NOAA Climate Services Lead

EXECUTIVE SUMMARY

The nation requires a comprehensive and coordinated approach to providing information to support adaptation, management, and mitigation of climate change and its impacts. NOAA climate services are needed to provide credible and authoritative climate information that will assist the nation, and by extension, the world, in developing and evaluating policy options for climate change mitigation and will enable decision makers, including resource managers and the public, to better anticipate, plan for, and adapt to impacts of a changing climate. NOAA climate services would serve a broad range of national needs for consistent climate change information. A range of public and private entities in sectors such as transportation, insurance, energy, water, fisheries, and agriculture are increasingly incorporating climate information into their planning. NOAA climate services are needed to provide improved public information and education on climate change so that American citizens better understand the causes, impacts, and implications of climate change for their lives and decisions, and have a better understanding of the differences between natural climate variability and human-induced climate change.

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. NOAA has key science and stewardship responsibilities for coastal and marine ecosystems. NOAA has the scientific underpinnings, infrastructure, and delivery mechanisms required to develop a coordinated and integrated agency-wide 'end-

to-end' climate services strategy. A guiding principle of NOAA climate services is that it will provide dedicated coordination of information relating to climate change across the breadth of NOAA, including capabilities in atmosphere and ocean science and services, coastal zone and ecosystem management and stewardship, assessment, and information delivery and infrastructure.

NOAA recognizes that climate policy and climate change research planning are evolving rapidly at a national level. To best serve the nation, NOAA must be flexible in its planning and be prepared to coordinate in new ways. NOAA alone cannot meet all of the nation's needs for climate information and services; partnerships from federal to local levels, including other agencies, the academic community and private sector will be essential to fully meet the nation's needs.

NOAA is willing and able to participate as a leader in a broader national enterprise, and brings forward existing major capabilities. Climate change is a global challenge, and NOAA will continue and expand its work with international partners.

The overarching goal of NOAA's climate services is to provide the essential climate change information needed for effective decision making. Working with its partners, NOAA climate services must ensure core infrastructure to support products and services: a climate observing system, data management and delivery, research, modeling, assessments, public understanding, and outreach/technical assistance. NOAA's climate services

must seek to identify an early suite of products and services (development time of less than five years) that can assist a number of key social, economic, and environmental climate change decisions, particularly those at regional and national levels. It is also clear that addressing climate change will require evolving needs for information to support decision making over not just a few years but over many decades. NOAA's climate services must progressively inform an ever-increasing number of adaptation and mitigation questions and customers.



NOAA's climate services 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. They are:

What We Will Do...

- Be an “honest broker”.
- Focus on anthropogenic climate change, but link anthropogenic climate change and variability to meet broad user needs.
- Provide products and services to minimize climate-related risks.
- Provide predictions and projections relevant to decision support.
- Strengthen observations, standards, and data stewardship.
- Ensure timely assessments.
- Inform policy options.
- Inform regulatory decisions and management options of others.
- Foster climate literacy and workforce development.

In a Manner That...

- Commits to a service-centric approach.
- Balances present and future information needs (shared learning between users and providers).
- Encourages public-private partnership.
- Ensures robust products grounded in sound science, fostering sustained collaborations with partners including those in other agencies and academia.

Requirements...

- Maintain an open and engaged scientific capability.
- Support problem-focused research.
- Characterize uncertainties.



This document focuses on

 the rationale
 for climate
 services within
 NOAA and the
 strategic goals and principles
 governing its structure, but
 does not discuss specifics of
 implementation.

1. Why Establish NOAA Climate Services?

There is unequivocal evidence that the Earth is warming. This warming has been manifested by increases in global-average surface air and ocean temperatures, widespread melting of snow and ice, rising sea level, and changes in numerous other climate-related variables and impacts (IPCC 2007). Most of the observed increases in global temperatures since the mid-20th century are very likely due to human-induced emissions of greenhouse gases (IPCC 2007). Under a broad range of non-mitigation scenarios considered by the IPCC, warming over this century is projected to be substantially larger than over the past century. Changes in many other components of the climate system, precipitation patterns being but one example, are also very likely to be larger than those observed in the present century.

The prospects of such climate changes¹ have profound implications for global society and the environment, 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. Among the most fundamental of such decisions is the future U.S. position regarding participation in the ongoing process of the international Kyoto Protocol and United Nations Framework Convention on Climate Change.

Within the U.S., extensive climate-related changes have been documented over the last century (USGCRP 2009). 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 snowmelt, and altered river flow volumes.

The nation currently lacks a comprehensive and coordinated approach to providing information to support adaptation, management, and mitigation of climate change and its impacts. Climate services are required within NOAA to provide credible and authoritative climate information that will assist the nation and by extension the world in developing and evaluating policy options for climate change mitigation and that will enable decision makers, including resource managers and the public, to better anticipate, plan for, and adapt to impacts of a changing climate.

¹*Climate* in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. In this report, *climate change* refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or land use (IPCC 2007).

Future impacts of a changing climate are expected to be regionally diverse and relevant across numerous sectors, including water, energy, transportation, forestry, coasts, fisheries, agriculture, ecosystems, and human health (USGCRP 2009). These impacts are anticipated to grow in response to projected future climate change, so that wise adaptation planning is required (see Figure 1).

Addressing these challenges will require access to the best climate knowledge and information that science can provide. While varying capabilities for providing climate information exist in federal agencies and various organizations, it is difficult for decision makers to know where to turn for reliable information. NOAA climate services are required to provide credible and authoritative climate information that will assist the nation and by extension the world in developing and evaluating policy options for climate change mitigation and enable decision makers, resource managers, and the public to better anticipate, plan for, and adapt to impacts of climate change and variability.

NOAA climate services are envisioned to provide balanced scientific information, building on NOAA's existing experience as an 'honest broker' in climate science, assessment, and services. Decision makers and planners will benefit from the consistent and authoritative information to be provided by NOAA climate services on a host of specific issues such as changes in high-impact climate and weather events (see Box 1), coastal impacts, and marine ecosystem impacts.

NOAA's climate services would serve a broad range of national needs for consistent climate change information. A range of public and private entities in sectors such as transportation, insurance, energy, water, fisheries, and agriculture are increasingly incorporating climate information into their planning. Government agencies require climate change information to meet their statutory requirements. NOAA climate services are needed to enable the nation to proactively prepare for and reduce climate-related impacts and losses. NOAA climate services are needed to provide improved public information and education on climate change so that American citizens better understand the causes, impacts and implications of climate change for their lives and decisions, and have a better understanding of the differences between natural climate variability and human-induced climate change. A more climate-literate and proactive citizenry will foster successful policy and planning on scales ranging from communities to cities, states, and the nation as a whole.

Impacts of both climate change and variability are not only being felt now but will very likely evolve in scope as well as in character (e.g., changes in extremes) in the next few decades. Rapidly developing science is constantly bringing forward new issues and challenges, such as ocean acidification, that the government and the public need to take into account in their planning. There is an *urgent* need for NOAA climate services that anticipates and responds to these national needs.

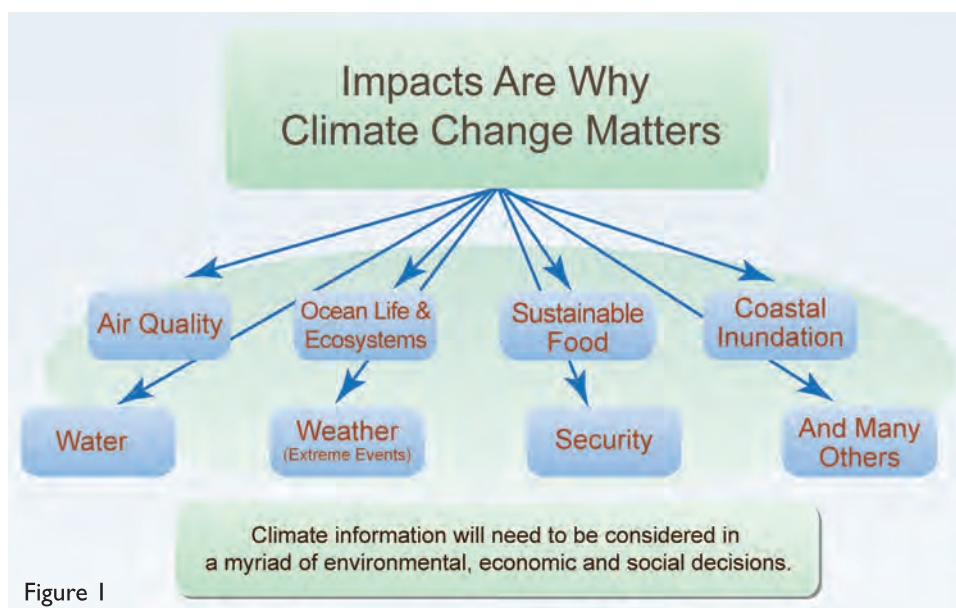


Figure 1

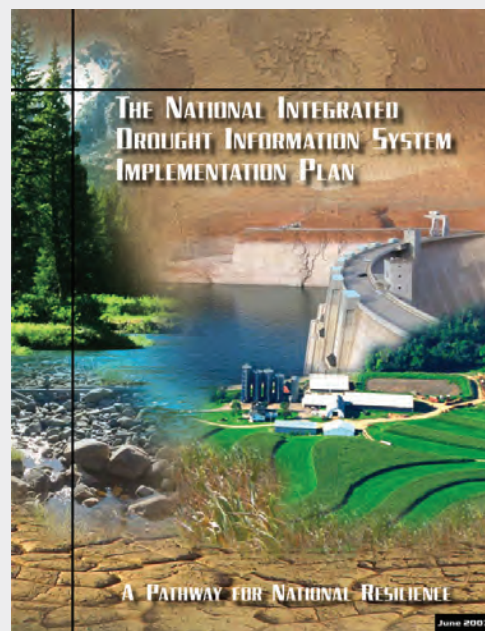
Box 1 – Climate Change and Water Resources

Climate change is expected to have major impacts on future water resources. Findings of the U.S. Global Research Program (USGCRP 2009) include:

- Climate change already has altered, and will continue to alter the water cycle, affecting where, when, and how much water is available.
- Floods and droughts will become more common and intense.
- In mountain areas where snowpack dominates, the timing of runoff will shift to earlier in the spring and flows will be lower in late summer.
- The past century is no longer a reasonable guide to the future for water management.

Such changes will place additional burdens on already stressed water systems, such as portions of the southwestern United States, where there is growing scientific evidence that the region may experience an increasingly arid climate in the 21st century.

NOAA is leading an effort with many partners to proactively address one of the major climate-related water issues, drought, through the development of a drought early warning system. This National Integrated Drought Information System (NIDIS) is in response to needs articulated by the Western Governors Association and in the NIDIS Act of 2006. Through interagency participation (federal and state agencies, local government, regional and state climate offices, and academia) in the NIDIS Planning and Implementation Team, NIDIS is positioned to build on successes of experimental and operational products for monitoring and predicting droughts and their impacts. These efforts provide a foundation for developing monitoring, attribution, predictions, and impact assessments to support drought-related climate services at national, watershed, state, and local levels.



2. Why NOAA?

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. NOAA's mandate for climate activities was established by the National Climate Program Act of 1978 (amended 1986). NOAA is the only federal agency with capabilities spanning atmospheric and ocean sciences and has science and stewardship responsibilities for coastal and marine ecosystems, thus providing many of the scientific underpinnings required for effective climate services. NOAA currently provides multiple capabilities and coordinates with other agencies and partners, but more capability and coordination are needed (see Sections 3 and 4).

As the lead federal agency responsible for delivering national weather, ocean, fishery, coastal, satellite, and environmental data products and services for informing decisions, NOAA has unique breadth of mandate and experience in environmental service delivery that provides a strong foundation for many types of climate services. NOAA works closely with an extensive user community from national to local levels, an essential prerequisite for creating effective services.

Weather forecasts, seasonal outlooks, interannual-to-decadal predictions, and climate change projections require observations, models, and understanding of the same Earth system. NOAA has established a strong and sustained capability and infrastructure in many of these areas, positioning the agency to create synergy and coordination where appropriate between its evolving weather services and climate services. Distinguishing between natural variability and trends is essential to

informing both adaptation and mitigation decisions. NOAA's existing strengths in research on both natural variability and human-induced climate change put the agency in a unique position to make these vital distinctions based on the best science available.

NOAA has a range of capabilities to address key impacts such as coastal hazards, ocean acidification, droughts and floods, and climate/air quality links, to name but a few. This collection is a unique national resource. NOAA's coastal and marine resource managers are among the vanguard of users of climate information, and are natural partners in understanding and planning for the impacts of a changing climate (see Box 2). Among its numerous management responsibilities, NOAA implements federal marine fisheries management under the Magnuson-Stevens Fishery Conservation and Management Act, ocean use and protection under the National Marine Sanctuaries Act, marine mammal management under the Marine Mammal Protection Act, endangered species management under the Endangered Species Act, and coastal and estuarine management under the Coastal Zone Management Act. With each of these mandates, NOAA managers must account for the effects of climate variability and change on coastal and marine ecosystems, resources, and communities, and adapt their management practices accordingly. Conditions and processes of concern affected by a changing climate include: ocean temperatures, water levels in coastal regions and the Great Lakes, sea and lake ice cover, ocean current patterns, freshwater supply, saltwater intrusion, atmospheric extremes, occurrence of hypoxia and harmful algal blooms, and changes in disease patterns.

NOAA has an exceptional record of leadership in climate change science and services to offer

as a component of a broader climate services enterprise. NOAA has a long tradition of leadership in international science assessments, including the World Meteorological Organization/United Nations Environment Programme Scientific Assessments of Ozone Depletion and the Intergovernmental Panel on Climate Change (IPCC) climate assessments, which have played and can be expected to continue to play major roles in national and international policy decisions. NOAA has also played a primary role in the U.S. Global Change Research Program and the U.S. Climate Change Science Program (CCSP), leading several of the CCSP synthesis and assessment products, including *Global Climate Change Impacts in the United States* (USGCRP 2009).

While there is no comprehensive national strategy for monitoring climate change, NOAA currently maintains most of the nation's sustained climate observing networks. These include a patchwork of operational satellites and in situ networks for integrated atmospheric and oceanic observations, including measurements of greenhouse gases, aerosols, and ozone. The agency depends on international and national partners for other sustained observations relevant to climate change, variability and impacts, such as ground-based water information and space-based research measurements. NOAA maintains the nation's permanent archive of weather, climate and oceanographic data through its data centers, which also host World Data Centers for Meteorology, Paleoclimatology and Oceanography. NOAA ensures the continuity and integrity of the historical climate record through data stewardship. NOAA provides analyses of the observed records, including the nation's climate statistics and reanalysis of observations and initial conditions for climate prediction. It also makes major contributions to the process studies required to attribute the causes of climate change.

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. A guiding principle of NOAA's climate services is that it will provide dedicated coordination of information relating to climate change across the breadth of NOAA, including capabilities in atmosphere and ocean science and services, coastal zone and ecosystem management and stewardship, assessment, and information delivery and infrastructure.

Box 2 – Sea-Level Rise and Coastal Hazards

Rising sea levels will inundate coastal communities, erode beaches, intensify flooding, and increase the salinity of estuaries, bays, and groundwater. Coastal floodplains have the largest repetitive flood losses and greatest potential for catastrophic losses due to the higher density and value of development along coasts and to high-impact hazards including hurricanes and tsunamis.

Rising sea level produces a higher base for storm surge and diminishes the rate at which areas drain, increasing the risk of flooding from rainstorms. Sea-level rise will exacerbate shoreline erosion by diminishing protective features such as dunes and wetlands. NOAA is poised to provide products and services for monitoring sea level change and for helping decision makers respond to the impacts. Examples include:

- **Monitoring Data and Predictions:** Pulling together consistent baseline data across the federal government and serving as a trusted resource in providing predictions for decision making.
- **Risk and Vulnerability Assessment:** Information on how sea-level rise will affect risks associated with extreme events (floods, hurricanes) and impacts (social, economic, structural) will provide the scientific foundation for evaluating investment options.
- **Decision Support Tools, Maps and Visualizations:** Visualization products and decision support tools are essential to ensuring the usefulness of information for public works investments and green infrastructure such as land conservation and resource restoration.



The benefits to be gained from providing these climate services for decision makers include reduction or avoidance of losses from uninformed investment decisions, implementation of adaptation strategies that will outweigh the costs of inaction, and identification of adaptation options with multiple benefits such as reducing shorter-term disaster losses in addition to future climate impact costs.

NOAA has extensive experience in building sustained partnerships with external communities and in eliciting and validating user requirements for the development and delivery of useful products and services. Indeed, NOAA has a history of producing climate information, delivering products and services, and building the capacities of others through the networks and partnerships it has established at all levels. Existing products and services include climate data services, climate predictions and climate change projections, assessments, and decision support information. Existing networks include NIDIS (see Box 1), 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, the Pacific Climate Information System, the International Research Institute for Climate and Society,

and other extension agents. The scope and nature of user interactions and partnerships required to address climate change demand an extraordinary investment in ensuring continuous feedback and joint adaptive learning between users and providers.

These examples illustrate that NOAA has a unique basis to develop a coordinated and integrated ‘end-to-end’ climate services strategy. Without an integrated service, policy makers and decision makers will struggle to make informed decisions required to mitigate and adapt to the effects of climate change and variability. An integrated service requires that NOAA organize its resources and coordinate them with its partners to ensure that the future delivery of climate services and information anticipates and is responsive to user needs, is transparent, and is based on the best available science.

3. What: The Goals and Scope of NOAA's Climate Services

The overarching goal of NOAA's climate services is to provide the essential climate change information needed for effective decision making. Scientific information to assist environmental decision making has three fundamental components: credibility ("Is it real?"); manageability ("What can we do about it?"); and accountability ("Did the solutions taken work?"). NOAA's climate services must address all three components.

NOAA's climate services consist of products and services and the core infrastructure upon which the products and services are built. Working with its partners, NOAA's climate services must ensure that the following core components of an end-to-end climate service are planned, built, and sustained:

- a climate observing system;
- effective data management and delivery systems;
- research that underpins the service and establishes the scientific feasibility of evolving products;
- climate modeling for predictions and projections;
- regional, national, and international assessments;
- public understanding; and
- user outreach and technical assistance.

NOAA's climate services must also improve integration and communication of climate-related information across the breadth of NOAA.

A near-term goal of NOAA's climate services must be to initiate a continuing assessment of key regional 'pressure points' important for impacts on the nation and potentially strongly affected by anthropogenic climate change (such as increased drought in the southwest and associated fire danger, flooding risks, and agricultural impacts in the Midwest, and hurricane trends affecting the East and Gulf coasts). NOAA's climate services must assess, and work to improve, the credibility and communication of the regional climate projections to address these impacts. NOAA's climate services must also provide information to support accountability, such as verifiable changes in greenhouse gas concentrations due to mitigation decisions.

As the climate change challenge evolves and broadens, a key goal for NOAA's climate services is to be both highly responsive to user needs and able to lead based upon expert evaluation of new data and knowledge. This requires that NOAA's climate services develop products and services that can evolve, and be initiated rapidly when needed, in response to scientific information as it emerges. A balance respecting the dual demands of 'user-pull' and 'science-push' must guide the nature and scope of the services.

To build and maintain the bridge linking information and users, NOAA's climate services must provide products and services that meet 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 have an operational flavor; others will involve assessments of the state of climate research. This section provides illustrations of products and services and is not meant to be comprehensive.

The set of criteria for choosing NOAA's climate services and products include all of the following in rank order:

- (i) likely connections to decisions relating to anthropogenic climate change
- (ii) magnitude, scale, and likelihood of the impacts of climate change and variability on society and the environment
- (iii) established strengths of NOAA to lead in providing the indicated products and services
- (iv) the need for a comprehensive mix of products and services to inform both mitigation and adaptation.

NOAA's climate services must seek to identify an early suite of products and services (development time of less than five years) that can assist a number of pressing social, economic, and environmental climate change decisions, particularly those at national and regional levels. Products and capabilities that NOAA's climate services might provide include:

- the National Integrated Drought Information System (see Box 1);

The overarching goal of NOAA's climate services is to provide the essential climate change information needed for effective decision making. NOAA's climate services must seek to identify an early suite of products and services (development time of less than five years) that can promptly assist a number of pressing social, economic, and environmental climate change decisions, particularly those at regional and national levels. It is clear that addressing climate change will require evolving needs for information to support decision making over not just a few years but over many decades. NOAA's climate services must progressively inform an ever-increasing number of adaptation and mitigation questions and customers.

- improved sea level predictions and impacts information to enhance coastal zone management (see Box 2);
- development and initial implementation of tools to evaluate possible inadvertent impacts as well as co-benefits of proposed mitigation options (e.g., release of nitrous oxide from biofuels or air quality/climate co-benefits that could be gained from reductions in soot emissions);
- an early-warning system to document ocean acidification and evaluate related ecosystem impacts (see Box 3); and
- an improved Arctic sea ice monitoring and analysis system allowing evaluation of coastal erosion threats and linkages to Arctic ecosystem changes.

Box 3 – An Ocean Acidification Observing Network for Climate Services

The same anthropogenic increase in carbon dioxide concentration in the atmosphere that is causing climate change is also forcing more carbon into our oceans, causing changes in seawater chemistry known as “ocean acidification.” Ocean acidification presents a separate suite of environmental changes that will affect ocean ecosystems, fisheries, and other marine resources in profound ways, such as reducing the ability of many organisms to build their shells, and changing organisms and ecosystems in ways that affect the carbon and nitrogen cycles. The seriousness of this issue has only recently been recognized, but the scale of potential impacts has led to consistent appeals from the scientific community, both nationally and internationally, to escalate ocean acidification research and monitoring. In open-ocean environments, acidification has reduced the ability of marine algae and planktonic animals to produce their protective shells. As these organisms are important food sources to commercial fish species such as salmon, ocean acidification could have important consequences for the larger marine food chain. The economic consequences of these ecosystem-scale impacts of ocean acidification could reverberate through the U.S. and global economy. This rapidly emerging scientific issue has raised serious concerns across the scientific and fisheries resource management communities as to possible ecological and economic impacts. More accurate and reliable predictions of the rate, severity, and ecological impact of ocean acidification are needed to improve forecasts of ocean pH conditions over this century and the consequences for marine organisms. These forecasts are in turn required to assess the corresponding socioeconomic impacts and develop adaptive management strategies for our fish and shellfish industries. NOAA has demonstrated leadership capabilities as well as instrumentation and platforms to achieve many research and monitoring goals. An essential component of NOAA's plan is to establish ocean acidification monitoring stations at strategic open-ocean and coastal sites designed to characterize the carbon chemistry and track changes in these ecosystem responses in particularly vulnerable regions including coral reefs, estuarine and coastal, regions.



It is clear that addressing climate change will require evolving needs for information to support decision making over not just a few years but over many decades. NOAA's climate services must progressively inform an ever-increasing number of adaptation and mitigation questions and customers. Illustrative examples of products and services that could be provided over the longer term include:

- development of improved Earth system models and predictive capabilities across temporal and spatial scales;
- a comprehensive suite of long-term monitoring records of climate system variables, ecosystem impacts, and gases/aerosols;
- improved evaluation of feedbacks that may accelerate or reduce climate change;
- scientific assessments and products aimed not only at physical science and impacts, but also at the resilience of communities, sectors, and natural resources (e.g., corals, fish, etc.) to changing climate conditions;
- a dedicated and flexible climate statistics database to support sound planning for future national, regional, and local infrastructure investments; and
- investments in climate awareness, capacity building, education, and outreach programs that enhance climate literacy.

4. With Whom and How

NOAA recognizes that climate policy and climate change research planning are evolving rapidly at a national level. To best serve the nation, NOAA must be flexible in its planning and be prepared to coordinate in new ways with other agencies, the Office of Science and Technology Policy (OSTP), the Council on Environmental Quality and the Assistant to the President for Energy and Climate Change, academic and private sector partners, as well as with regional, state, and local entities.

The scope of the full range of challenges posed by climate change far exceeds the authority, capability, and resources of any single organization. NOAA alone cannot meet all of the nation's needs for climate

NOAA recognizes that climate policy and climate change research planning are evolving rapidly at a national level. NOAA alone cannot meet all of the nation's needs for climate information and services; partnerships from federal to local levels, including other agencies, the academic community and private sector will be essential to fully meet the nation's needs. NOAA is willing and able to participate as a leader in a broader national enterprise, and brings forward existing major capabilities. Climate change is a global challenge, and NOAA will continue and expand its work with international partners. NOAA's climate services must follow a clear set of principles regarding its products and services, to ensure that it remains appropriately focused and managed in an effective way.

information and services; partnerships from federal to local levels, including other agencies, the academic community and private sector will be essential to fully meet the nation's needs. NOAA is willing and able to participate as a leader in a broader national enterprise, and brings forward existing major capabilities. Climate change is a global challenge, and NOAA will continue and expand its work with international partners.

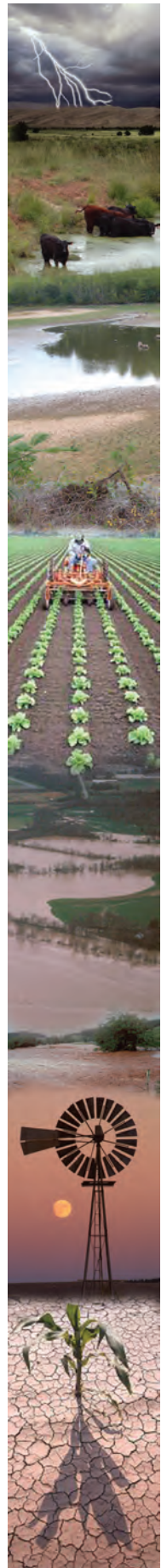
There are many areas of climate change policy, research, and services where NOAA's work could complement that of others in a support role (e.g., health, forestry, agriculture, etc.). A focused dialogue with agency, university, and private sector partners could be helpful in such planning, and NOAA could serve in a convening role. Experience has shown that scientific assessment processes provide an especially useful way to develop the kind of expert dialogue that can lead to improved interdisciplinary information and approaches. NOAA has experience that could be brought to bear in using assessment mechanisms as initial steps contributing to developing the way forward to a national program.



NOAA's climate services 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. Based on Sections 1-3, the following are considered to be strategic principles for NOAA's climate services:

What We Will Do...

- ***Be an “honest broker.”*** NOAA's climate services must provide balanced and credible scientific and technical information, building on NOAA's existing experience as an honest broker in science, assessment, and services.
- ***Focus on anthropogenic climate change, but link anthropogenic climate change and variability to meet broad user needs.*** NOAA's climate services must be focused upon anthropogenic climate changes. In order to meet the needs of the broadest set of users who require climate information that links anthropogenic climate change and variability, NOAA's climate services must also coordinate the generation of information relating to climate across the breadth of NOAA. For example, the scope of NOAA's climate services includes projections of future changes in the frequency, intensity, and life cycle of El Niño/ Southern Oscillation (ENSO) events, as well as public information on how long-term climate trends and ENSO may jointly contribute to drought events, but it does not extend to operational ENSO forecasting. NOAA's climate services must leverage, integrate, and expand NOAA's resources to enrich climate products and services as needed.
- ***Provide products and services to minimize climate-related risks.*** NOAA's climate services must provide products and services to help minimize risks of climate change, including identifying key climate change impacts as well as informing effective adaptation and mitigation options.
- ***Provide predictions and projections relevant to decision support.*** NOAA's climate services must provide climate predictions and projections and their associated uncertainties at the temporal and spatial scales needed for climate change decision support including detection and attribution, as justified by the state of climate change science.
- ***Strengthen observations, standards, and data stewardship.*** NOAA's climate services will strengthen existing agency commitments to sustained global and national climate observations using the essential climate variables and climate monitoring principles defined by the Global Climate Observing System (GCOS) as a foundation; these data will be supplemented with regional and local observations. NOAA climate services will provide high quality scientific stewardship for the data records it maintains, especially in the context of addressing specific climate-related challenges and will work with relevant NOAA programs, international partners, other federal and state agencies, academia, and the private sector to support and enhance networks for physical, biological, and social data needed to address climate change.
- ***Ensure timely assessments.*** NOAA's climate services must participate in and/or lead the provision of timely assessments of climate change, climate change impacts and vulnerability, mitigation, and adaptation, and in turn, must derive information from these assessments.
- ***Inform policy options.*** NOAA's climate services must provide products and services to inform climate change mitigation and adaptation policy options today and enable ongoing verification of their effectiveness.



- ***Inform regulatory decisions and management options of others.*** NOAA's climate services will not have any regulatory authority. NOAA's climate services will provide information to assist regulatory decisions and management options to other parts of NOAA (e.g., NMFS) as well as to other agencies and entities ranging from local to federal (e.g., EPA, DOI).
- ***Foster climate literacy and workforce development.*** In collaboration with partners, NOAA's climate services will build upon the agency's strong outreach capacity to foster a broad national effort to extend climate literacy and will enhance workforce development required to meet growing national climate needs.

In a Manner That...

- ***Commits to a service-centric approach.*** NOAA's climate services will provide effective means for understanding user needs in key problem areas and communicating climate information at temporal and spatial scales relevant for decision making. User requirements will be identified collaboratively and iteratively through ongoing dialogues with decision makers, the research community, the climate services, and its other partners. At each stage of product evolution, thorough assessments must be undertaken to ensure product robustness, and a feedback system will be instituted for continuous product improvement. The products must have a clearly defined delivery mechanism that is proven during the prototype phase. A clear need must be established for a new product or to continue an existing product, as shown by users making decisions based on the product.
- ***Balances present and future information needs (shared learning between users and providers).*** NOAA's climate services will be managed in a manner that balances responding to user needs with a program of science and assessment that evaluates readiness and identifies new needs as scientific insights evolve. NOAA's climate services must ensure an ongoing dialogue between users and providers to accomplish shared learning and joint problem solving.

- ***Encourages public-private partnership.*** NOAA's climate services will develop and maintain a public-private partnership to clarify respective roles and encourage the introduction of value-added climate change-related products and services by the private sector.
- ***Ensures robust products grounded in sound science, fostering sustained collaborations with partners including those in other agencies and academia.*** All products and services will be backed by sound science and by scientists and experts with proven track records on the subject. Science and the scientists needed for producing and maintaining key products and services must be supported by NOAA's climate services through a commitment over the long term, sufficient to facilitate and ensure the integrity and longevity of the product. NOAA's climate services will be committed to early engagement of and sustained collaboration with core partners, including those in other agencies and academia.

Requirements...

- ***Maintain an open and engaged scientific capability.*** NOAA's climate services will need to ensure openness and engagement in climate change science to be credible and flexible, and to avoid insularity.
- ***Support problem-focused research.*** NOAA's climate services will support research that has clear linkages to well-posed climate change problems related to impacts, vulnerability, mitigation, and adaptation.
- ***Characterize uncertainties.*** To accurately characterize the uncertainty as required for climate risk management, NOAA's climate services must take advantage of and draw from the multiplicity of approaches to climate modeling and generating climate data records. For example, recent authoritative assessments (IPCC 2007) have demonstrated the importance of multi-model ensembles in climate projections and multiple climate data records.

References

IPCC (Intergovernmental Panel on Climate Change), 2007: *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, UK, and New York, 996 pp.

USGCRP (United States Global Change Research Program), 2009: *Global Climate Change Impacts in the United States* [Karl, T.R., J.M. Melillo, and T.C. Peterson (eds.)]. Cambridge University Press, New York, 188 pp.

Acronyms

CCSP: Climate Change Science Program

DOI: Department of the Interior

ENSO: El Niño/Southern Oscillation

EPA: Environmental Protection Agency

GCOS: Global Climate Observing System

USGCRP: United States Global Change Research Program

IPCC: Intergovernmental Panel on Climate Change

NIDIS: National Integrated Drought Information System

NMFS: National Marine Fisheries Service

NOAA: National Oceanic and Atmospheric Administration

NWS: National Weather Service

OSTP: Office of Science and Technology Policy

UNEP: United Nations Environment Programme

USDA: U.S. Department of Agriculture

USP: Unified Synthesis Product

WMO: World Meteorological Organization

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