Executive Summary

The first Climate Information Responding to User Needs (CIRUN) – NOAA Executive Roundtable was convened on November 29th, 2012, in College Park, MD. The meeting, held at the University of Maryland’s Earth System Science Interdisciplinary Center (ESSIC) and attended by representatives of the government, business, and academic sectors, had the stated goal of connecting providers of climate information with decision makers. Participants discussed which of NOAA’s climate products and information they currently use, and what improvements and new products would help them better address their needs. NOAA representatives provided an overview of current products and operations, as well as plans for the next one to two years. Discussion was lively throughout the day, and the participants were enthusiastic about the potential for substantial outcomes.

The meeting participants described their use of a wide variety of NOAA products and other sources of climate information as input in their forecasting and risk modeling calculations. Examples of these risk-based decisions included adapting current operations, short-term management of water resources, and longer-term planning for new facilities and projects. The difficulty of obtaining climate information from the diverse array of sources was viewed as a challenge, as was the fact that the varying resolutions, formats, and quality of data require extensive post-processing. Desire was expressed for finer resolution, both spatial and temporal, greater consistency, watershed- and basin-scale data, and a clearer representation of the uncertainty in climate products. As well, understanding the potential return on investment for adapting to changing climate is critically important to most users.
Several proposed actions resulted from the day’s discussion. In general, it was agreed that the accessibility of NOAA’s services and products in a user-friendly format needs to be improved, and that there is a need for a “bridge” between data providers and applications. An Application Test Bed where climate science could be applied to real problems was suggested as one possible “bridge”. Participants expressed a real interest in NOAA’s ongoing needs-assessment project, which NOAA is using to develop priorities based on the services that users most want. Industry representatives suggested the development of a user-focused slide presentation containing information about climate challenges, NOAA’s products, and the need for continuing services from NOAA. Several follow-up actions were outlined. In particular, a detailed description of NOAA’s needs-assessment process has already been sent to participants, and development of the user-focused slide presentation is in progress.

Table of Contents

Executive Summary ............................................................................................................................................1
Opening Session ..................................................................................................................................................4
   CIRUN Background and Roundtable Purpose .........................................................................................4
   NOAA Overview .........................................................................................................................................5
FIRST SESSION: Current NOAA Climate Products .........................................................................................7
   Specific Examples of Using NOAA Data .........................................................................................................7
   General Discussion of NOAA Data ................................................................................................................9
SECOND SESSION: Future Climate Products .....................................................................................................11
   Where is NOAA Headed in the Next 1 - 2 years? .........................................................................................11
   What are the Future Climate Products that NOAA Should Produce? ..........................................................12
THIRD SESSION: Where Are We Now? ............................................................................................................14
   State of the Science .......................................................................................................................................14
   Identifying the Needs of the Community ........................................................................................................14
FOURTH SESSION: Building a Bridge .............................................................................................................16
   Connecting Users to Climate Information ......................................................................................................16
   “Building a Bridge between NOAA’s Information and User’s Decisions” ..................................................17
Summary and Follow-Up Actions ....................................................................................................................18
Acknowledgments ............................................................................................................................................19
Glossary of Acronyms ......................................................................................................................................20
Appendix 1: Roundtable Participants ..............................................................................................................21
Appendix 2: Roundtable Agenda ......................................................................................................................23
Appendix 3: Questions from Organizations and Answers from NOAA ..........................................................24
Appendix 4: Status of NOAA Climate Products and Services ..........................................................................49
Appendix 5: The NOAA Climate Prediction Center ..........................................................................................61
Appendix 6: The NOAA National Climatic Data Center ..................................................................................70
Opening Session

The Roundtable opened with welcoming remarks from Guillermo (Willy) Accame, Director of Risk Management at the Panattoni Development Company, who chaired the meeting. The participants introduced themselves (a list of participants is appended to this document).

CIRUN Background and Roundtable Purpose

Steve Halperin, Director of the Climate Information Responding to User Needs (CIRUN) Initiative at the University of Maryland, described CIRUN and outlined the objectives for the Roundtable. CIRUN was established with the vision of connecting climate science with decision makers. The purpose of this Roundtable was to provide leaders from the public and private sector the opportunity to engage in a day-long exchange with senior representatives from NOAA and university climate scientists with the objective of informing the decision makers about what information is available from NOAA and how to get it, and to provide NOAA an opportunity to receive feedback from decision makers regarding their needs and priorities. In preparation for the Roundtable participating decision makers provided NOAA with a list of questions to which NOAA provided answers which were distributed in advance as background. These are appended to this report.

Antonio Busalacchi, Director of the University of Maryland’s Earth System Science Interdisciplinary Center (ESSIC), provided a brief overview of current weather and climate prediction. A greater understanding of the dynamics of the atmosphere ushered in the National Weather Service (NWS). Private sector weather prediction has grown over the past 20-30 years and is currently a $2 billion business. Climate science as well has developed substantially over the past three decades, and many countries around the world have established national climate services. In the U.S., NOAA is continuing the development and provision of climate services and products. Busalacchi emphasized the importance of developing a culture of climate science in service to society. For so many years, the climate science community has had a “loading dock” mentality: they produce weather and climate products, make them available, and wait for users to come. Now it is important to change this to make it user-driven, so as to better serve society. Hence the three communities in attendance here.
NOAA Overview

Wayne Higgins of NOAA’s Climate Prediction Center (CPC) provided an overview of NOAA’s priorities, current products and services, and where climate information can be found within NOAA.

**Rising Demand for NOAA’s Climate Services:** There is an urgent and growing need for reliable, trusted, transparent and timely climate information across all sectors of the economy. Increasingly, decision makers are using this information to make decisions at the local and regional scale, and NOAA has information, products, and services that they can use.

**NOAA’s Four Societal Challenge Areas:** NOAA is addressing societal challenges in four key areas: sustainability of marine ecosystems, coasts and climate resilience, climate impacts on water resources, and changes in extremes of weather and climate. NOAA has established a Climate Goal Board to assist with setting NOAA’s strategic priorities and with determining resource commitments for the four societal challenge areas. The Board has established Executive Working Groups and Project Leads for the four societal challenges to set requirements and develop project plans.

**NOAA’s Core Assets and Capabilities:** NOAA sustains fundamental capabilities, including research to advance understanding of the Earth System, observations to preserve and build the climate data record and monitor changes in the Earth’s atmosphere and ocean, and climate models to improve predictive capabilities across space and time scales. NOAA has a suite of forecast products spanning weather and climate to provide support for impact-based decisions.

**Where to go in NOAA for climate products:** The Climate Prediction Center (CPC) is the only national climate service center within the National Centers for Environmental Prediction (NCEP). CPC works collaboratively with the other national service centers at NCEP (which are primarily focused on weather time scales) to provide a suite of products and services to support impact-based decisions. The other centers are:

- Aviation Weather Center (AWC)
- Hydrometeorological Prediction Center (HPC)
- Ocean Prediction Center (OPC)
- Storm Prediction Center (SPC)
- Space Weather Prediction Center (SWPC)
- Tropical Prediction Center (TPC)

NOAA prioritizes user needs against NOAA’s expertise to identify focused improvements in science-based decision support products and services. NOAA will continue to engage stakeholders and provide integrated science-based climate information, services, and tools to more effectively help communities, governments, the private sector, and others understand and plan for the impacts of a variable and changing climate.
CPC, The National Climatic Data Center (NCDC), Coastal Services Center (CSC), National Marine Fisheries Service (NMFS), and the Climate Program Office (CPO) all provide climate products and services. For examples of these products and services, participants were referred to a hardcopy distributed at the meeting.
FIRST SESSION: Current NOAA Climate Products

Risk modeling is a critical use of NOAA’s data by managers in many sectors. In the near term, they determine which facilities should be strengthened against the risk of weather and climate extremes, and how future water supplies should be planned for. In the longer term, siting and development of facilities such as power plants, factories, or reservoirs are influenced by sea-level rise, drought prediction, expected frequency and intensity of extremes, and other factors. Participants detailed their use of historical data, current monitoring, and outlooks. In many instances, users are forced to evaluate forward funding project improvements or enhancements to protect against the risk of future weather and climate extremes that may or may not materialize. These are critical decisions that can be very costly, and NOAA has information that can help industry evaluate alternatives and benefits.

Specific Examples of Using NOAA Data

Many of the Roundtable participants are working with utilities, resource managers, government, and the consulting community to evaluate the potential impact of changing climate on their operations. Understanding of possible future exposure to climate extremes is of crucial importance. Several of the participants’ work includes planning and managing water supply and wastewater treatment facilities and utilities, as many of these facilities are located at sea level. Participants use gridded data, including Reanalyses, PRISM, as well as many others. They also use historical information, and work toward adjusting to historical extreme event frequencies. This includes long-term historical and future projections at local scales, and on daily to monthly to decadal timescales. Participants are particularly interested in gridded data with higher resolution, both spatial and temporal. One specific field they use is sea-level change information for infrastructure planning, including historical sea-level and storm surge data, and projections of sea-level change. All this information is used as input into risk models for specific applications, including regulatory risk, land-use planning risk, and levy infrastructure. Combinations (called ensembles) of climate models and/or derived fields are then sometimes used to estimate uncertainty.

Accame discussed the commercial real estate uses of NOAA’s services and products. Short- to mid-term trends in climate extremes are very important to the real estate sector and help guide siting and construction practices.

Gary Scoggin of British Petroleum (BP) said, as an oil and gas organization, they are concerned both with their impact on climate and society, and climate and society’s impact on them. Their facilities have a 30-50 year lifespan, and so they make large-dollar decisions for projects which will last
for decades. In many areas, the water supply is essential, and therefore forecasts on the long-term development of water resources are needed. “What kind of water supply can we expect?” is a major question. They must design now for sea-level rise over the life of the facility and also need to understand how much risk they are exposing themselves to.

Matthew Arnold of JP Morgan Chase (JPMC) said his company uses NOAA’s data in managing their global assets. On the immediate time scale, their focus is making operations more robust, and they invest resources to promote natural resilience. When they underwrite a transaction, it is JPMC’s job to understand the long-term risk to the investment. Arnold indicated further that while changing climate produces business risk, these private equity investment risks can actually be terrific business opportunities. An example of this is hydraulic fracturing or “fracking”, which is a new water use in already constrained water communities. If further constraints on water impact the ability to produce energy, new technologies will emerge that could make good investments. He asked how they can implement a systematic education program within JPMC so that they can talk about climate to their 50 million customers. He also suggested that the NOAA attendees think about outreach, about the users who are synthesizers, not analysts, and about how to leverage what NOAA produces into easy to understand graphics.

Fernando Miralles-Wilhelm of ESSIC offered the observation that adaptation is being interpreted as a cost, but can also be seen as an investment. He asked the participants “how do we quantify the return on investment? Whose task is it to develop this information?” Accame replied that it is industry’s job, as the investors, to complete this task.

John Quinn of Excelon Corporation said that the energy and utilities community is critically dependent on weather and climate. The nation depends on them, and many of their energy supply contracts are long-term, spanning 20 or more years. Water availability and the frequency and intensity of extremes are important to the energy and utilities community. For new facilities, forward-looking risk planning is incorporated, but for existing ones, NOAA’s products are used to quantify risk when completing upgrades.

Many Roundtable participants expressed a great interest in water-related information. The water management community, represented by Laurna Kaatz of Denver Water and Rolf Olsen of the Army Corps of Engineers (USUSACS), uses NOAA products and services for the decision-making process for moving water and controlling dams. Specifically, CPC’s 10-day and seasonal forecasts and ENSO and MJO forecasts can potentially be used for daily, monthly, and annual planning for USUSACS reservoir management. They use RISA programs and NIDIS program for guidance and translation, and to articulate policy questions back to the research community. As well, monitoring of temperature and precipitation are essential for their operations: especially real-time, observed data feeds directly into their systems. NOAA’s climate data is critical, since if a forecast is wrong, the population and businesses counting on that water supply are at risk of shortages. They called for better characterization of uncertainty in all climate projections.

Bruce Karas of The Coca-Cola Company said they are very interested in watershed-level water information. Watershed information such as hurricane data in Florida can be useful in building incident management response tools.
Frank Lowenstein commented that The Nature Conservancy uses NOAA’s information as input into global downscaled models, specifically NOAA’s Coastal Services Center (CSC) sea-level rise and storm surge forecasts. They are interested in how natural systems interact with storm surges. As well, they look at fire risk and water availability, and metrics for the scale of future extreme events.

Scott Tew of Ingersoll Rand Company said their use of NOAA data includes planning for the development of facilities such as healthcare facilities, military bases, and energy grids. They also use shorter-term products, including CPC extended forecasts of precipitation predictions and NCDC predictive forecasting.

**General Discussion on NOAA Data**

Several themes arose from the session’s discussion. Tom Karl remarked that it seemed participants were asking for products with not just better resolution in time and space, but also greater consistency. The difficulty of collecting data was raised, as many users have to go to several different locations to fulfill their data needs. It was also observed that data on NOAA’s websites seems often to be presented for scientists, and that it would be helpful if information were presented more graphically. NOAA was urged to consider whom they’re trying to educate, and to focus on sustainability, with a greater opportunity to teach people.

The need for improved characterization of uncertainty in forecasts and variability was mentioned several times. Integrating across data sets with different spatial and temporal resolutions, as well as bias removal, is a great challenge for users, and it would be helpful if producers provided the information in a more user-friendly format. It was pointed out, however, that merging datasets can result in a degradation of accuracy. Developing international common standards for data has been a long-term goal for NOAA, but even the definition of “standard” can be broadly interpreted. It can mean an assessment of the quality of a product, or the way the data are produced.

Finally, funding is a great challenge in the current fiscal environment. It was clear to all participants that if future funding for NOAA’s observational capabilities is cut, the degree to which current climate products will continue to be available would be affected. This potential interruption or diminution in the continuity of the current climate data being provided by NOAA was of great concern to the business community as well as to the scientific community. The ability to predict unusual environmental events such as Sandy’s left hand turn into the United States was seen as crucially important, and it was recognized that at a minimum this required the maintaining of the ground and space and observational systems.
SECOND SESSION: Future Climate Products

Where is NOAA Headed in the Next 1-2 Years?

The second session began with an overview of the Societal Challenge areas identified by NOAA.

**Climate Impacts on Water Resources:** Roger Pulwarty of NOAA discussed this challenge area. Efforts are being made toward improving forecast reliability for droughts and floods; diagnosing the role of precipitation events and land surface conditions in amplifying or reducing the severity of drought and flood impacts; developing timely, accessible communication tools and impacts assessments (to support water, food, energy security and disaster risk reduction); and to employ existing cross-sectoral (interagency, state, private and tribal) partnerships to improve coordination for prioritizing and advancing monitoring, forecasts and impact assessments from watersheds to the coasts. An important question to ask is: where, when, and how often should the robustness of our physical infrastructure be assessed?

**Climate and Coastal Resilience:** Margaret Davidson of NOAA spoke about this challenge area. There is a focus on easily accessible total water-level related information. Data from many sources, including some counties, are aggregated in one website, csc.noaa.gov/digitalcoast. This data is variable with time: for example, water levels on the East coast are rising 60% faster than predicted in the models. She also observed that there is a need to broaden our understanding of all timescales.

**Changes in Extremes of Weather and Climate:** Tom Karl of NOAA’s National Climatic Data Center addressed this challenge area. It is important to ask who is using our data. The primary user of our in situ data is the private sector, and the primary user of satellite data is the government. The primary user of radar data is the university community, followed by the private sector, and then government entities. What this tells us is the level of ability of users to make use of this data. For example, the big satellite data sets require more understanding, and the government has more comfort in using them. Efforts are ongoing to identify focused improvements in science-based decision support products and services. These efforts include developing visualizations and data products that convey changes in weather and climate extremes, and developing a monitoring strategy that ensures continuity of observations for those key extremes needed to inform risk management. As well, it is a priority to establish reliable estimates of confidence, ensure access for use in risk modeling frameworks, and improve skill by advancing understanding of weather and climate extremes. Also prioritized is enhancing access to, and understanding of, the current state of knowledge about extreme weather and climate events for key audiences. He stressed that NOAA cannot do it all, and so is asking how do they do the greatest common good, while letting the private sector take the next steps.
**Sustainability of Marine Ecosystems:** Roger Griffis of NOAA spoke on this challenge area. Their focus is on the production, delivery and use of climate information to support decisions related to the sustainable use of valuable natural marine resources. Marine ecosystems are directly responsible for $200B in economic activity and millions of jobs. NOAA is concerned with fisheries management both recreational and commercial, protected species recovery, and conservation of habitat. In carrying out their responsibility for marine resources, NOAA works with three levels of government: state, tribal, and federal, and with the relevant parts of the private sector.

**What are the Future Climate Products that NOAA Should Produce?**

Mandy Ikert of C40 Cities said that in urban planning, adaptation to climate change is a relatively new area, and they are developing plans for future resilience. City planning timeframes are primarily five-year spans, water resource, wind, and solar heat information are useful fields that already exist. One tangible tool that they need is something that lets them see return on investment for soft-scaping vs. hard-scaping. Davidson replied that this is under development, in the form of an economic and environmental analysis of the valuation of ecosystem services. Ikert also pointed out that U.S. cities are now looking at 20 and 30 year periods to respond to climate change and are very interested in climate risk assessment including localized climate forecast data. Thinking globally, she said, we need risk modeling tools that we can use internationally.

Pulwarty pointed out that cumulative impacts of small events are just as important as the big impacts of single events. We need to discuss how events affect the productivity of businesses.

Davidson said that a six-month snowmelt forecast would be very valuable for ecosystem management in the Mississippi River Basin.

Karas asked the participants to consider the intersection of NOAA’s four Societal Challenge areas. What are the probabilities ten years out? Scoggin replied that while the four areas do converge, they have second- and third-order effects when they come together.

Lowenstein suggested we pursue the idea of integration, including social and economic information. This would involve considering changes in the built environment and population distribution, integrating information from the Census and the EPA, and looking at impacts across climate variables. As an action item, NOAA could participate with a set of businesses to develop a case study.

In the ensuing discussion, it was suggested that an “application test bed” in the style of the Climate Test Bed (CTB) is needed, to transition data and research into decision-making tools, and that the parties in the CIRUN Roundtable provide an opportunity to develop such a collaborative prototype. The idea of collaborating on an application test bed was supported by numerous participants.
THIRD SESSION: Where are we now?

State of the Science

Xin Zhong Liang of ESSIC began the afternoon’s discussion. He stated that there are many different kinds of simulations, and we can give a very good estimate of uncertainties. However, uncertainty is one thing, and accuracy is another. We are currently combining many different kinds of simulations with different configurations, allowing for further understanding of uncertainty. Climate scientists compare 30-year hindcasts to individual forecasts, to find which configuration results in the most accurate outcomes. However, while we can have a standard wherein the model accurately reproduces the past, we don’t know if it’s accurately projecting the future. Universities are not competing with NOAA; rather, they’re editing in post-process the data that NOAA is providing. We’ve published papers, but we don’t have the money or the human resources to put our most promising research ideas into daily practice. There is not an effective process to transition the results of university research into NOAA’s operations.

Karl reiterated the importance of data standards, and how a secondary field (such as evaporation) depends on a primary field (wind) that may have large inhomogeneities. We need to identify priorities in order to develop standards. Higgins suggested that a data mining effort, reaching back into paper records, could greatly improve the historical record.

Pulwarty referred to a question originally posed by Kaatz: where do standards of practice come in? Reconciling different projections about the future does require standards of practice. He named several considerations, including “not just doing the wrong thing with better data”, and knowing what’s wrong, more than just knowing what we don’t know. He said that the NOAA weather model development process of research – prototype – delivery doesn’t seem to apply simply and directly to climate models, and asked how far can public servants go? A greater collaboration with universities and the private sector is required; however, NOAA’s Regional Climate Centers and Regional Integrated Science and Assessment (RISA) programs do pull in these communities.

Identifying the Needs of the Community

Paul Scholz said that the Coastal Service works with decision makers. There is a difference between a want and a need, and the root need must be identified for NOAA to respond. Social scientists can identify these needs, and they should be included. It’s a social-science oriented process, not a physical one. In response to a participant’s suggestion Karl stated that NOAA does not currently have a grand strategy for outreach, such as organized attendance at trade conferences.
Tim Baden of FEMA (Federal Emergency Management Agency) described their recent report, “Crisis Response and Disaster Resilience 2030”. FEMA pulled in participants from across the emergency management community to evaluate what future emergency response should look like. Their scenarios went out to 2030 and they identified the common denominators for what we should focus on in the future. Climate change was the leading environmental challenge identified. The report states that the emergency management community faces increasing complexity and decreasing predictability in its operating environment. Other examples of focus areas included demographic shifts such as an ageing and moving population; mega-regions; government budgets; and globalization, including supply chains. The recommendations included pulling in community groups that are very powerful but may not be the most obvious, such as the Knights of Columbus, an organization with 1 million members.

FEMA has ongoing discussions and three focus areas: 1) Grant streams to look at climate change, including benefit-cost analyses, to provide standards at the local level; 2) more partnerships down to the local level; and 3) risk assessments to address anticipated changes in risk, rather than just historical risk. Historical risk may be used to represent future risk, but may not be representative of what is to come. Nancy Colleton of IGES supported this comment, saying the insurance sector’s underwriting also needs to adjust because it has been based on historical risk, which may no longer be an accurate basis for future risk.
FOURTH SESSION: Building a Bridge

Connecting Users to Climate Information

Higgins said there have been efforts trying to connect users to climate information, including problem-focused pilot programs, but what’s been missing is a sustained effort to provide translational information and the necessary internal infrastructure. A successful example connecting NOAA with users was the monthly webinars held during the most recent La Niña. This pilot was part of a NOAA effort to establish a National Climate Predictions and Projections (NCPP) Platform that connected users and climate scientists in collaborative problem solving and which leveraged open-source and open-community approaches.

Accame asked, “What is the role of the consulting community in building a bridge between the data and the users?” Armin Munevar of CH2M Hill suggested this was a business opportunity: no one thought in 20+ year timescales years ago, but now there is enough investment potential to produce these bridging tools. He stated that, in fact, the investment is already being made, repeatedly. It is important that collaborative work be done to identify where the bounds are, what the bridging tools looks like, so translation doesn’t need to be redone. The proprietary nature of developed products could present a hurdle; however, sometimes results can be put in the public domain.

Kaatz pointed out that Hurricanes Sandy and Katrina have shown us we aren’t even prepared for current climate, and now we have to consider how to prepare for future climate. A big issue is the general failure by scientists to communicate important scientific information to the non-scientific community, and most specifically as this relates to extremes. She highlighted the need to understand the characteristics that led up to specific events, and to answer the question: “what did we know that let us see something was coming and how might those signals change over time?”

There are some examples of success, and Joseph (Joe) Russo of ZedX, Inc. described the development of standards for exchanging agricultural data between computers and platforms, the first set of which should come out in the spring of 2013. These were developed with the assistance of independent consultants and the government. It was also suggested that large information technology companies such as IBM or Google that know how to handle large amounts of data would be valuable partners in building a bridge.

Karl said that while there is a lot of close collaboration between CPC and NCDC, there are gaps. Specifically, they don’t work with the community to try and provide information in a usable way (with quantified uncertainty). There are major research challenges that we need to be looking at and it would be helpful to get guidance from industry on what they need.

Munevar remarked that some of the most extensively used climate data, for example NOAA Atlas 14 and ocean level data, aren’t being updated with current science.
Building a “Bridge” between NOAA’s Information and Users’ Decisions

There was some discussion about the difficulty of answering the question “what products and services do you need from NOAA?” Scoggin suggested we need to create a bridge between the data that NOAA is good at producing and the decision-maker. “I may not know what [products and services] I need, but I know what I need to get done and the decisions that I need to make.” Hence, we need to create that bridge. How do we understand when value is created? We need an interactive process.

Karl reminded participants of the fiscal environment in which they are operating today, and that not only is it challenging to produce new services, but it may even be difficult to maintain current operations. Halperin replied that the only way this situation is going to change is if leaders in the business community are very clear about talking with the Administration and U.S. Congress about how important climate services are.

The National Integrated Drought Information System (NIDIS) was pointed out as an example of how NOAA could interact with the public; several agencies are working together on this project. Kaatz suggested that another example of a bridge is the translation of science into application, and application into policy. An extra level of professionals is required to do these translations, and utilities and other sectors are starting to hire people to do this. She cautioned that users don’t always understand the limitations of the data. It was stated that it is not NOAA’s responsibility to translate the information, but that it is NOAA’s responsibility to write the “warning labels”.

Halperin listed two examples of existing bridges: academic scientists consulting with private engineering companies, and weather companies. Many of the latter grew up out of university faculty start-ups. The climate area is new, but bridges will likely develop in this area as well.

Summary and Follow-Up Actions

The group concluded with a discussion of some activities to help increase the usability of NOAA’s services and products and to build a bridge between data providers and applications.

1. Develop a more user-focused “Needs Assessment”. It was observed that this would have to be carefully designed. It would need to be scoped to clearly distinguish between priority needs and wants, and should involve social scientists. NOAA is currently fast-tracking a NOAA needs assessment for extremes. Subsequent to the Roundtable, information about this project was sent to participants, so that they could provide feedback, and ask the opinions of other leaders in their respective industry sectors.

2. Prepare a 15-30 slide presentation that will seek to make NOAA’s climate resources more broadly understood. The crucial role of NOAA’s observational capability was stressed, and the danger that budget cuts could result in reducing this, with serious consequences for NOAA’s
forecasting ability. It was proposed that perhaps the first slides cover the scope of the problem, and the remaining ones describe the range of NOAA’s current contributions, and what more could be done with additional resources.

3. **Explore the idea of an “Application Test Bed”**. This was suggested by Raghu Murtugudde, ESSIC. It would be a place to transition the latest results of climate models to applications in a limited number of areas. Potentially, this could serve as one model for the “bridge” discussed during the meeting. It was suggested that CIRUN undertake this, and look at successful examples of NOAA test beds and use those as a starting point for how to move forward. Halperin welcomed the suggestion and encouraged anyone interested in participation to contact him.

4. **Consider publishing an editorial as a follow up to the Roundtable discussions.**

Several wrap-up comments were made. Specific data requests from users included greater grid resolution in space and time, including at regional and watershed scales, and more data on the availability and temperature of water, and on land-atmosphere interaction. The development of regional Earth System models was seen as important, and it was recommended that in the production of climate information, attention be placed on the role of watersheds as a multi-sector integrator. Extreme events and changes in extremes were of critical interest to nearly everyone. Greater quantification and characterization of uncertainty, including structural uncertainty, was also viewed as important.

The importance of integration over several fields, including data products, timescales, and NOAA’s branches, was emphasized throughout the day. How can NOAA resources be made more broadly available, accessible, and usable? There is a need for a clearinghouse for information across sectors, a seamless approach to information services, and feedback on such a system. It was recommended that NOAA identify standards of practice: this is the role of the government. The “gold standard” should come from NOAA.

Understanding the return on investment over the long term for climate adaptation was a recurring theme. It is important to look at the impact of climate adaptation on private sector productivity; in the private sector, investments need to demonstrate returns. Making this case will make it possible for industry leaders to move on adaptation efforts. Participants emphasized the need to “speak the right language”: when one asks business leaders what they are doing about climate adaptation, they often can’t respond, but if asked about “emergency preparedness” or “disaster recovery”, they generally respond with ease.

**Acknowledgements**

Accame wrapped up the day by thanking the individuals at CIRUN, ESSIC, and NOAA who worked tirelessly to organize and execute the Roundtable. Halperin then thanked Accame on behalf of CIRUN for his signal contribution in recruiting participants and leading a highly productive day-long discussion. The two rapporteurs, Emily Becker and Stephanie Herring, both of NOAA, are gratefully
acknowledged. This report was prepared by the two rapporteurs and then revised to take into account comments from the participants.
Glossary of acronyms

AMO: Atlantic Multidecadal Oscillation
CIRUN: Climate Information Responding to Users’ Needs
CONUS: Contiguous United States
CPC: Climate Prediction Center
CPO: Climate Program Office
CSC: Coastal Services Center
ENSO: El Nino Southern Oscillation
ESSIC: Earth System Science Interdisciplinary Center
FEMA: Federal Emergency Management Agency
CGM: General Circulation Model
IPCC: Intergovernmental Panel on Climate Change
JPMC: JP Morgan Chase
MJO: Madden Julian Oscillation
NCDC: National Climatic Data Center
NCEP: National Centers for Environmental Prediction
NIDIS: National Integrated Drought Information System
NMFS: National Marine Fisheries Service
NOAA: National Oceanic and Atmospheric Administration
NWS: National Weather Service
PDO: Pacific Decadal Oscillation
RCC: Regional Climate Center
RISA: Regional Integrated Sciences and Assessments
USACE: United States Army Corp of Engineers
Appendix 1: Roundtable Participants

EXECUTIVE ROUNDTABLE PARTICIPANTS
for
CLIMATE INFORMATION RESPONDING TO USER NEEDS

NOAA
- Head of the Climate Prediction Center (Dr. Wayne Higgins)
- Head of the National Climatic Data Center (Dr. Tom Karl)
- Acting Director of the Climate Program Office (Dr. Rick Rosen)
- Director of the Climate Test Bed (Dr. Jin Huang)
- Executive Working Group or Project Leads for the four NOAA priorities:
  - Sustainability of Marine Ecosystems (Roger Griffis)
  - Climate and Coastal Resilience (Margaret Davidson, Dr. Paul Scholz)
  - Climate Impacts on Water Resources (Dr. Roger Pulwarty)
  - Changes in Extremes of Weather and Climate (Dr. Tom Karl)

University of Maryland – Earth System Science Interdisciplinary Center
- Dr. Antonio Busalacchi, Director, ESSIC
- Dr. Steve Halperin, Director, CIRUN
- Dr. Xin Zhong Liang, Professor
- Dr. Raghu Murtugudde, Professor
- Dr. Fernando Miralles-Wilhelm, Professor

Organizations
- Agriculture Information – ZedX, Inc. – Joseph Russo, President
- Commercial Real Estate – Panattoni Development Co. – Guillermo Accame, Director
- Commercial Water Use – The Coca Cola Company – Bruce Karas, Vice-President
- Ecosystems – The Nature Conservancy – Frank Lowenstein, Strategy Leader
- Communication/Education – Institute for Global Environmental Strategies – Nancy Colleton, President
- Emergency Response/Planning – Federal Emergency Management Agency (FEMA) – Tim Baden, Director
- Energy/Utilities-Excelon Corporation – John Quinn, Senior Manager
- Engineering/Construction – CH2M Hill – Armin Munever, Vice President
- Finance – JPMorgan Chase – Matthew Arnold, Managing Director
- Industrial/Supply Chain – Ingersoll Rand – Scott Tew, Director
- Oil and Gas – BP – Gary Scoggin, Director
- Ports - Maryland Port Administration – Jim Dwyer, Deputy Director
- Urban Planning – C40 Cities – Mandy Ikert, Director of Water and Adaptation
Appendix 2: Roundtable Agenda

CIRUN-NOAA Executive Roundtable

November 29, 2012

Agenda

Chair: Guillermo Accame

8:00-9:00  Continental Breakfast
9:00-9:05  Introduction and welcome (Guillermo Accame)
9:05-9:10  Objectives and logistics (Steve Halperin)
9:10-9:15  Welcome to ESSIC and UMD (Antonio Busalacchi)
9:15-9:30  Summary of NOAA products today (Wayne Higgins)
9:30 -10:30 Interactive discussion connecting user needs with current NOAA products
10:30-10:45 Break
10:45-11:00 Summary of NOAA’s plans for future products (Roger Pulwarty, Margaret Davidson, Tom Karl and Roger Griffis)
11:00-12:00 Interactive discussion about user priorities for NOAA future products
12:00-1:30 Lunch
1:30-2:30  Follow-up on participant questions and answers from NOAA
2:30-3:00  Break
3:00-4:30  Follow-up on participant questions and answers from NOAA
4:30-4:45  Summary (Antonio Busalacchi)
4:45-5:15  Wrap-up
5:15-6:45  Reception
6:45-8:45  Dinner
Climate Impacts on Water Resources

1. Precipitation is a crucial piece of water resources management. One general finding from projection analysis is that “wetter regions will get wetter, and drier regions will get drier.” The enhancement – intensity, duration, and occurrence – of extreme precipitation events is important to our daily, seasonal, annual and long-term planning. In particular, we use the intensity, duration and occurrence of past droughts to help us determine how reliable our system is under strained conditions. How are droughts and extreme precipitation events going to change in the United States in the future? How are they going to change in the seven basin states relying on the Colorado River? More importantly, why can we not answer this question specifically and what do we need to do to make this happen? (Lead: Roger Pulwarty – Chad McNutt)

A: Projections of future climate indicate that a positive trend in the frequency of heavy precipitation is likely to continue over many areas of the globe, including parts of the U.S., in the 21st Century. Observed precipitation over the last several decades also shows positive trends. As discussed below, however, not all regions of the CONUS or all seasons are projected to have increases in heavy precipitation events. Wang and Zhang (2008) used the IPCC A2 scenario to examine 20-year return intervals for maximum daily precipitation. They found that both winter extreme precipitation and winter mean precipitation estimates from General Circulation Models (GCM) showed an increase in the northern U.S. and a decrease in the southern U.S. Additionally, the increase in extreme precipitation, in their study, was greater than that for mean precipitation. The result suggests that a 1-in-20 year extreme precipitation event currently is likely to occur more frequently in the future, becoming a 1-in-5 to 1-in-15 year event. Model results also point to small, or no, shifts in circulation regime, indicating that the change in extreme precipitation events will be related to increased moisture in the air due to warmer temperatures (Wang and Zhang 2008). This simple relationship has led to estimates of future precipitation likelihoods of a 2.5 degree F increase in air temperature leading to an increase of 20mm (0.8 in) per day in heavy precipitation change in the summer. Sub-areas of the Southwest are anticipated to experience reductions in runoff, streamflow, and soil moisture as a result of increases in temperature. Drought, as defined by Colorado River flow, is projected to become more frequent, more intense, and more prolonged. For a list of projected changes in the Southwest see Table 1.

Depending on the emissions scenario, model projections show average annual temperature increases of 1.4°F in the period 2021-2050, 1.6°F in 2041-2070, and 2.9°F in 2070-2099. Changes along the coastal zone are smaller than inland areas.

Model projections show the largest increases in summer and fall. The largest projected increases range from 3.5°F in the period 2021-2050 to 9.9°F in 2070-2099.

For all periods and both scenarios, model simulations show both increases and decreases in precipitation. For the region as a whole, most of the median values are negative, but not by much, whereas the range of changes, among different models is high. Annual precipitation projections generally show decreases in the southern part of the region and increases in the northern part.

Models project a reduction of late winter-spring mountain snowpack in the Southwest over the 21st Century, mostly because of the effects of warmer temperature.

Was not analyzed in report. Other projections imply diminished April 1 snow water equivalent in most Southwest river basins.

Observed Southwest droughts have been exacerbated by anomalously warm summer temperatures. Model projections of increased summer temperatures would exacerbate future droughts. Model projections show depletion of June 1 soil moisture and lower total streamflow.

Uncertainties related to projected trends are large in some cases. GCMs agree in most locations and seasons on the sign of the changes in temperature indices and quantiles, but changes in precipitation are more uncertain. Model agreement of at least 90% generally only takes place in northern High Latitudes (IPCC 2007). In much of the Tropics and the Mid-latitudes, agreement, even on the sign of the changes, seldom exceeds 66% among the different models used by the IPCC. For other moisture-related parameters, such as soil moisture, model agreement is poor, with a few exceptions (Orlowsky and Seneviratne, 2011). Model uncertainty is generally the dominant source of uncertainty for the longer time-scales while scenario uncertainty is found to be relatively small for all regions and time-scales, apart from close to the poles at the end of the century. Brekke and Barsugli (2012) showed a similar result for the CONUS for typical annual maximum-daily precipitation (1daymax) with 2-yr return period and for extreme 1daymax with a 100-yr return period.

The signal-to-noise ratio (S/N) of precipitation projections is highest at the poles and less than one almost everywhere else and is lowest in the tropics. In general S/N is much lower than those for temperature projections. Hawkins and Sutton (2011)
estimated a potential S/N for regional precipitation and show gains in S/N are fairly minor especially for projections in the coming decades. This has implications for adaptation strategies in that they will need to be made in the context of high uncertainty concerning regional changes in precipitation.

2. Precipitation projections for watersheds in Colorado are all over the place – about half showing wetter conditions and half showing drier conditions in the future. Additionally, the range in magnitudes of these projections is immense making it significantly more challenging to include this variable as we plan for the future. As we ask for better, more actionable information, it is becoming more important to tease out specific processes and modeling capabilities that need to be improved to meet our informational needs. This is important so we can both track the processes that influence our seasonal, annual and longer-term decision making, but also so we can engage with researchers to focus on these needs. What are the key processes that influence precipitation projections in Colorado? We are familiar with ENSO and somewhat with PDO. We also understand the limitation in GCM projections and the need for improved modeling on the Tropical Pacific and improved decadal prediction. (Lead: Roger Pulwarty-Chad McNutt)

A: This is a difficult issue to parse. One additional factor not mentioned in the question is the influence of the Atlantic - a warm North Atlantic (as observed since 1995) in combination with a cold (La Niña-like/negative PDO; since 2005) Pacific, which favors dry conditions in much of Western U.S. There is at present no reliable projection of how climate change will affect the different modes of variability (i.e. PDO, ENSO, AMO), although the next decade will likely remain under the negative PDO/positive AMO configuration, which is not favorable for wet conditions. Some of the uncertainty with regard to future climate change is also a function of the lack of consensus on future ENSO trends. If La Niña-like conditions are favored, the lower elevations of Colorado would likely end up being drier, while the mountains could receive enough moisture in the winter to balance out the lack of precipitation during most other seasons under that scenario. Regarding precipitation under increased temperatures (and GHG-forcing), there is also the issue that warmer winter storms could end up providing for more moisture, mostly still falling as snow, at least into the middle of the 21st century, but those same higher temperatures could lead to increased evapotranspiration and reduced soil moisture, which could negatively affect spring runoff.

3. Watersheds are a key piece of water resources infrastructure and are vulnerable to many impacts - forest fires, droughts, intense rain events, beetle kill, development, vegetation changes, etc. What are the key areas of concern for watersheds in the future and how are those anticipated to impact the conversion of precipitation into streamflow? (Lead: Roger Pulwarty-Chad McNutt)

A: Climate variability and change can influence average temperatures and temperature extremes; timing and spatial patterns of precipitation; snowmelt, runoff, evaporation, and soil moisture; the frequency of disturbances, such as drought, insect and disease outbreaks, severe storms, and incidence of wildfire; atmospheric composition and air quality; and patterns of human settlement and land use change. A good example of these interacting processes and their effect on runoff/streamflow can be seen in snow-dominated watersheds of the western U.S., where the bulk of precipitation falls on forested and alpine areas. Changes to those watersheds can have serious impacts on the conversion of precipitation to streamflow, both in terms of quantity and quality. Research by the Western Water Assessment and collaborators has shown that dust generated from the high desert of the Colorado Plateau and transported via wind on to Rocky Mountain snowpack can reduce streamflow in the Upper Colorado River Basin by up to five percent while also advancing snowmelt timing on the order of 3-4 weeks (Painter et al. 2010). Bark beetle infestations, which are affecting huge portions of western North America, are generally expected to result in greater water yield and greater peak flow at certain times, although those results have yet to be demonstrated convincingly at the scale of entire watersheds (Pugh and Gordon 2012). Finally, high-severity wildfires generally increase water yield, peak flows, and low flows from affected watersheds but often result in dramatic increases in sedimentation and other undesirable changes to water quality (NRC 2008). Added to the significant hydroclimatic variability already present in much of the western U.S., these changes can affect overall streamflow patterns in ways that are currently difficult to predict.

4. For long-range planning in many resource management problems, it is necessary to utilize gridded, high resolution climate projections to drive analyses at the watershed-scale. Our firm is often performing such analyses to evaluate watershed hydrology changes, vegetation changes, and effects to water-energy-food resources. Projected trajectories of climate information relating to daily precipitation, temperature, wind, and meteorological parameters at 1 km or higher resolution are needed in order to perform such evaluations. A number of bias-correction and downscaling techniques are
available from various sources; however, none seem to address these issues of resolution and temporal scale sufficiently. How does NOAA view their role in provision of such data? It appears that agencies such as Department of Interior and various national labs are leading this development in an ad-hoc fashion? Will a national standard data set be developed for such purposes? (Lead: Rick Rosen – Don Anderson)

A: NOAA, together with the Department of Interior (DOI), are working toward providing regional climate information and guidelines for its use. However, there are no credible gridded datasets available for predictions/projections at 1km spatial scale and daily predictions/projections.

The goal of both DOI and NOAA is to provide guidelines for the use of climate projections as input to, e.g., watershed-scale models/analyses. These models/analyses are in general developed independently by private, and state and local public sector communities. DOE, NSF, NOAA, NASA are engaged in both downscaling research and high resolution global modeling with a near term goal of providing guidelines for the application and use of these models at particular spatial resolutions. DOI, USACS, EPA, USDA also have a downscaling focus.

Examples of currently available datasets include the following websites:

Particularly for hydrological resources:

The site below is provided with cooperation of DOE Lawrence Livermore National Laboratory and provides rectangular gridded data. The site is straightforward to use and is broader in scope:

http://gdo-dcp.ucolnl.org/downscaled_cmip_projections/dcpInterfUSACS.html

Although the sites above are not ‘gov.certified’ they do provide current best estimates among the agencies and university community. The recently available site developed by USGS [http://cida.usgs.gov/climate/gdp/] does note the data have been reviewed by DOI, DOE, USACE and to the extent possible assure the integrity of these datasets.

The NOAA-led National Climate Predictions and Projections (NCPP) initiative [http://earthsystemcog.org/projects/ncpp/ ] has a goal of providing ‘gov. certified’ guidelines to assist in decision support.

5. How are water use demands anticipated to change in the future and why? (Lead: Roger Pulwarty – Chad McNutt)

A: Two major external trends that can affect future water demand include population growth (and associated urban, industrial and agricultural production needs) and production of energy. Other important trends include climate change; in-stream flows necessary to maintain ecosystem processes; and aging water supply infrastructure (see USACE, 2006, 2008). A recent update of population projections by the U.S. Bureau of Census shows an increase in the population of the lower 48 states of 81.8 million (or 29 percent) between 2000 and 2030. Within this increase there is a shift of 14.9 million people (18 percent of the increase) to the 17 western states. Florida, California and Texas are projected to gain more than 12 million people each, representing significant shifts above their year 2000 shares of total population of the contiguous U.S. Another source of uncertainty pertains to the unexpected and possibly abrupt shifts in demand caused by climate change and/or water demand for irrigation of crops. Approximately 20 percent of the U.S. land area is considered cropland. Of this, 14 percent of total cropland is irrigated. Also, climate change is expected to increase in some regions (e.g. Southwest) the frequency, intensity and duration of droughts. Future droughts may also create demands for irrigation water in areas of rain-fed agriculture, especially in the Great Plains region. Heat waves that often accompany droughts can also increase urban water demands. Increasing societal recognition of ecosystem services implies that in addition to future demand increases to provide for new population and economic growth, there will be increasing demand for in-stream uses of water to support aquatic ecosystems, provide for assimilative capacity to maintain water quality and also for recreational values. The demand for ecosystem uses will likely impact future allocations of water for off-stream uses and it may also curtail the current allocations of natural flow or water stored behind dams. Throughout the country, in-stream flow requirements are being established for specific reaches
or gauge locations and for specific time periods (months and shorter periods) for an increasing number of streams and rivers. The existing water supply infrastructure is aging and the main uncertainty related to this trend of aging relates to budget priorities of Federal and state governments that affect the availability of funds for the rehabilitation of dams and water conveyance facilities. Both of these factors can impact future water availability and use. If funds become available, then the water storage and transmission capacities of the existing facilities will be maintained or enhanced. Without funding the capacities will gradually decrease, especially if some facilities are decommissioned due to safety reasons. During the previous century many water projects had been built in the U.S., however the government’s budget realities seem to preclude the allocation of funds that are needed for rehabilitation of aging infrastructure. The decisions to fund rehabilitation of the aging infrastructure or investments in new projects depend on the budget priorities at all governmental levels. Federal funding for water projects has been declining since the 1960s (although there was an increase in funding construction of water and wastewater treatment). Water efficient infrastructure, technology and practices can help reduce the demands.

In addition to the major trends and uncertainties discussed above there are other factors that have the potential for affecting the U.S. future water supply and demand. These factors are related to: (1) technological advancements and breakthroughs, (2) unsettled Indian water right claims, (3) development of new water supply and transmission infrastructure and (4) international trade and demands for “virtual” water.

6. We understand there are numerous tools to assess corporate water risk (both temporal and spatial) but we understand these tools do not factor in groundwater data. In NOAA’s view is there a gap in groundwater data and how future availability may be affected by climate variations? (Lead: Roger Pulwarty – Chad McNutt)

A: Understanding the potential effects of climate variability and change on groundwater is more complex than with surface water. Even without considering climate variability and change, groundwater sustainability is a major challenge because groundwater is a widely distributed resource without clear point sources and is affected by local users and contamination. Another complicating aspect of groundwater is that water residence times can range from days to tens of thousands of years or more, which delays and disperses the effects of climate and challenges efforts to detect responses in the groundwater to climate variability and change. Furthermore, groundwater pumping and resulting loss of storage and capture of natural discharge are often on similar time scales as that of climate variability and change, which makes it difficult to distinguish between human and climatic stresses. For example, the magnitude and phase relation of ENSO, the Pacific Decadal Oscillation, and the Atlantic Multi-decadal Oscillation may result in average or extreme climate conditions that may affect drought, infiltration, recharge, discharge, and human demand for groundwater resources. Recent research efforts have characterized hydrologic and geochemical responses to climate variability on interannual to multidecadal time scales because variability on these time scales has the most tangible implications for groundwater resource management. Response of groundwater levels can be striking when climate variability from ENSO, PDO, and AMO coincide in a particular phase both from recharge and withdrawals. Such responses have been identified in aquifer systems of the Southwest and a number of other aquifers worldwide. Additional research is needed including a need to evaluate and understand climatic variability and change over the long term to better plan and manage groundwater resources, while taking into consideration the increasing stresses on groundwater resources from population growth and industrial, agricultural, and ecological needs. The interagency Climate Change and Water Working Group (CCAWWG) is currently conducting a user needs assessment of the critical climate information knowledge gaps facing the water management community. CCAWWG was formed with the goal of helping enhance water management through improved understanding of how climate variability and change will affect future hydrologic conditions and working to identify adaptation strategies to manage risks in conjunctive surface and groundwater systems.

References:


Orlowsky, B. and Seneviratne, S.I. 2011: Global changes in extreme events: Regional and seasonal dimension. Climatic Change ; 110 ; 669-696


Coasts and Climate Resilience

1. How and when will climate change impact flood plains and "storms of record", which are often the basis for facility design standards for marine cargo terminals and dredged material placement sites (islands) in the Chesapeake Bay? (Lead: Margaret Davidson – Nell Codner)

A: Climate change is already impacting flood plains and may be impacting storms of record. FEMA is charged with studying floodplains every five years to take change into consideration, but there are flood plain maps that are more than five years out of date. There are scientists who have been finding connections between climate change and water temperature increase, pointing towards climate change impacting the intensity of storms. More extreme events have been seen, most recently, Hurricane Sandy. The historical record is capturing the changes, but climate change is showing us that we can’t rely on the historical record to predict the future. We are still determining what is possible and probable in the future. The two factors that continue to affect the impacts of climate change are whether the land at the coastline is moving or sinking, and what people are doing to the land in terms of building, developing, preserving or any combination thereof.

Scenario planning is a useful tool that looks at plausible futures, instead of possible futures. In scenario planning, we remove the likelihood from the equation and instead look at the options of what could happen, how we would react and interact with this new world and determine how we would manage resources. Scenario planning started with Royal Dutch Shell, and the National Park Service has also been using it.

2. Storm surge, high winds, snow/rain fall, icing events, etc. have a negative impact on cargo operations (i.e. handling and storage) on a marine terminal. These weather events also affect truck and rail mobility getting to the terminals. Vessels navigating the Bay are also concerned with visibility, salinity (relates to water density), ice, currents, wind speed and direction, etc. How are these events likely to change in frequency and severity in the future? (Lead: Rick Rosen – Tom Peterson, Randy Dole, Marty Hoerling, and Chris Miller)

A: Storm surge and abnormally high or low tides are primarily of greatest concern to port operation, mooring facilities, and moored vessels. An additional contribution from sea level rise can influence vessel draft and cargo capacity, which is measured in terms of inches of water depth available to the vessel. Flooding from coastal storms results from a combination of storm surge and intense precipitation. Damage to inland structures, including transportation infrastructure, is largely dependent on storm surge elevation and penetration, exacerbated by the amount of local sea-level rise. It is likely that there has been an increase in extreme coastal high water related to increases in mean sea level. This contribution is additive to storm surge. Although global mean sea level has increased, there are significant regional differences in relative sea level rise due to regionally-specific winds, ocean circulation, land subsidence/uplift, etc. There is high confidence that locations currently experiencing adverse impacts such as coastal erosion and inundation will continue to do so in the future due to increasing sea levels, all other contributing factors being equal. The very likely contribution of mean sea level rise to increased extreme coastal high water levels, coupled with the likely increase in tropical cyclone maximum wind speed, compounds the risk of inundation. Structures whose design was based on the standards established from the 1960s/1970s may not meet design criteria for a 100-year storm calculated using more recent data.

There is medium confidence that there will be a reduction in the number of extratropical cyclones averaged over each hemisphere. While there is low confidence in the detailed geographical projections of extratropical cyclone activity, there is medium confidence in a projected poleward shift of extratropical storm tracks. Average tropical cyclone maximum wind speed is likely to increase, although increases may not occur in all ocean basins. It is likely that the global frequency of tropical cyclones will either decrease or remain essentially unchanged. There is low confidence in projections of small spatial-scale phenomena such as tornadoes and hail because competing physical processes may affect future trends and because current climate models do not simulate such phenomena.
The few studies of projected extreme winds, combined with shortcomings in the simulation of extreme winds and the different models, regions, and methods used to develop projections of this quantity, mean that there is low confidence in projections of changes in extreme winds. The exception is changes associated with tropical cyclones. It is likely that tropical cyclone-related maximum wind speed and rainfall rates will increase with greenhouse warming, although the conclusion for wind speed increases may not apply to all tropical areas. It is likely that the global frequency of tropical cyclones will either decrease or remain essentially unchanged. While it is likely that overall global frequency will either decrease or remain essentially unchanged, it is more likely than not that the frequency of the most intense storms will increase substantially in some ocean basins.

There is overall low confidence in wave height projections because of the small number of studies, the lack of consistency of the wind projections between models, and limitations in their ability to simulate extreme winds. Computation of changes in wind-generated waves reflect the uncertainty associated with changes in winds.

Frozen precipitation has the greatest impact of all weather-related parameters on transportation activities across all sectors. Warming will produce a side benefit of shifting more of the precipitation from snow to rain, which positively impacts transportation. Warmer temperatures mean a longer rain season and shorter snow season. As temperatures increase, the number of days below freezing will decrease. This will decrease the length of the snow season, reduce icing events, e.g., icing of ship superstructure, and lengthen ice-free periods on rivers, lakes, bays, etc. Less ice lowers the risk of hull damage to vessels and port facilities, facilitates navigation, and enables a longer navigation season. Fewer days with low temperatures will positively affect the marine transportation sector. In the simplest sense, air temperature of 0°C (32°F) or less impacts water-borne operations as water that splashes or sprays freezes on contact with vessels, decks, riggings, and accumulates as ice, making operations on deck dangerous and limiting the period for efficient transport. Additionally, ice fog can be extremely dangerous, stopping all deck activity.

Visibility is affected by rainfall and fog, and, in some locations, by wildfires. There have been statistically significant positive trends in the total amount of precipitation and the number of heavy precipitation events in some regions (see accompanying discussion in Question #10 in the section on Changes in Extremes of Weather and Climate). Fog is dependent on relative humidity and is influenced by the presence of nearby bodies of water like a lake or an ocean, so that its occurrence is very site-dependent. Warmer ocean temperatures may lead to more events of low visibility caused by sea fog in coastal areas. Regional projections of fog under future scenarios of climate change are not available.

Ocean currents, which affect navigation, and salinity, which affects buoyancy, may change in the future, especially on a regional basis, but studies are not sufficient to make statements about these changes with any confidence. High precipitation and runoff in wet periods could decrease salinity and lower the sea’s buoyancy and the levels at which ships float, thus offsetting the aforementioned benefit of sea level rise with respect to cargo load.

In general, there is large uncertainty in projecting future regional changes in extratropical cyclones, including coastal storms, snowfall, icing events, etc., due in part to competing mechanisms. The bottom line is that for many, but not all, of the weather phenomena mentioned there is either too little science or insufficient agreement to have confidence in projecting future changes, especially over the next several decades [see IPCC, Managing the Risks of Extreme Events and Disasters to Advance Climate Change (SREX), 2012, at http://www.ipcc-wg2.gov/SREX/, from which much of the above was drawn, for further information]. An overarching NOAA (and climate science) challenge is to develop better understanding and predictions of climate variations and trends at regional scales, including identifying the scales at which information becomes useful.

3. What climate change information is necessary in order to fully understand what retrofits or mitigating actions may be necessary to allow continued use of existing facilities/assets near the coast, i.e. within the flood plain? (Lead: Margaret Davidson – Nell Codner)
A: You can no longer assume that if you’ve previously been in a sheltered position that you will remain in a sheltered position. Distance from the ocean will mean longevity in a facility as exposure will lead to increased vulnerability. Information on whether the land is moving or subsiding will assist with determining local sea level change. Information on the relative and absolute elevation of the surrounding area will assist with determining whether the site is accessible in a storm (is the access road in a flood plain?) and whether related infrastructure, such as power lines, drains, in-takes or vents, is vulnerable. Understanding a site’s vulnerability and the vulnerability of the people who will be required to man these sites, as well as the economic importance of these facilities are all important factors in determining site-specific retrofits or mitigating actions, including relocation, which may be necessary.

4. Our firm assists many public and private clients to identify and adapt to risks associated with sea level changes. While we understand the uncertainties will continue to exist with respect to the magnitudes and regional aspects of sea level changes, two main information gaps exist in these assessments: (1) high, resolution mapping of elevation in coastal areas and (2) assessments of expansion (or contraction) of tidal range and changes to storm surge. Because most near-term sea level rise estimates are on the order of a couple of feet, the mapping of coastal elevation and vertical land movement is critical to detect such changes on the coastal landscape. In addition, since almost no infrastructure actually fails due to “mean” sea levels, it is the tidal range and tidal extremes that will drive infrastructure risk and investments. Our firm often applies coastal/estuarine hydrodynamic modeling to evaluate such risks, however, these efforts require significant investments that could be lessened through improved projection data from NOAA. What are NOAA’s plans in provision of such sea level change information? (Lead: Margaret Davidson – Nell Codner)

A: NOAA will continue to provide coastal mapping, coastal elevation data, and related models, projections, predictions, assessments tools, training and other related products and services to help users make informed decisions.
Changes in Extremes of Weather and Climate

1. What is NOAA’s view of the change in the Atlantic Basin / Gulf of Mexico hurricane frequency, both in recent decades and in the future? In particular, how will the 100 year wave height be affected and what affects do you anticipate on ocean currents? We are interested in this information to better inform our design criteria for both onshore and offshore structures and facilities. Our project development process includes consideration of climate change adaptation needs and this information will help us in that effort. (Lead: Wayne Higgins – Gerry Bell for 1.a; Hendrik Tolman for 1.b and 1.c.

1.a: What is NOAA’s view of the change in the Atlantic Basin / Gulf of Mexico hurricane frequency in recent decades?

A: Recent decades

Much of the recent increase in Atlantic hurricane activity began in 1995 as the tropical North Atlantic warmed and atmospheric conditions became conducive for increased hurricane activity, similar to the mid-20th century. When adjusted with an estimate of storms that stayed at sea and were likely “missed” in the pre-satellite era, there has been no significant increase in Atlantic hurricanes since the late 1800s.

The number of hurricanes that make U.S. landfall has not significantly increased or decreased either.

Causes: The historical record is dominated by large multi-decadal fluctuations in seasonal Atlantic hurricane activity. For example, there was increased Atlantic hurricane activity during 1880-1900, during the 1940s to the late 1960s, and again since 1995. Intervening periods of reduced Atlantic hurricane activity occurred during 1900-1930 and again during 1971-1994. These observed multi-decadal fluctuations in Atlantic hurricane activity are strongly associated with the Atlantic Multi-decadal Oscillation (AMO). The AMO is a variation in North Atlantic Ocean temperatures, with cool and warm phases historically lasting 25-40 years each. During the AMO warm phase, North Atlantic sea surface temperatures are unusually warm compared to the tropical average, and the atmospheric conditions over the Atlantic are conducive for increased Atlantic hurricane activity. During the AMO cool phase, oceanic and atmospheric conditions suppress Atlantic hurricane activity.

In 2010, the World Meteorological Organization (WMO) convened an expert team of hurricane-climate researchers to assess the causes of past changes in hurricane activity. The team concluded that “it remains uncertain if past changes in any tropical cyclone activity (frequency, intensity, rainfall, etc.) exceed the natural variability”.

A: Future

In 2010, the World Meteorological Organization (WMO) expert team of hurricane-climate researchers also reviewed climate model projections of potential 21st century changes in Atlantic hurricane activity. The team concluded that the 21st century climate model projections of Atlantic tropical storm frequency do not currently provide a consensus on future changes. Some models project increases of up to 60% in Atlantic tropical storm numbers, while others project decreases of up to 60%.

Studies available for the Atlantic basin suggest increased hurricane intensity, hurricane rainfall rates and the numbers of the most intense hurricanes over the 21st century. However, the projections for intensity, and especially intense hurricane numbers, have relatively large uncertainty and further research is needed to increase understanding.

Source: NOAA State of the Science FACT SHEET on Atlantic Hurricanes, Climate Variability and Global Warming
1.b: How will the 100 year wave height be affected?

A: There have been various studies on changing wave climate in the North Atlantic, with results varying from minor changes over the last century, to increases of wave height of up to 40% over the last century. The differences between these studies appear to be attributable to inhomogeneity in the data sets used. High-quality data from buoys and altimeters consist of too short a record to make strong statements about climatological trends, and may show local trends attributable to changes in storm tracks, but no general trends basin wide. Wave records based on atmospheric reanalyses are suspect with respect to wave hindcasts performed with them, as higher waves are extremely sensitive to the most extreme winds (99 percentile and above), which are not particularly homogeneous in reanalyses.

With the latter in mind, hurricane conditions contribute significantly to design criteria along the Atlantic Seaboard, and in the Gulf of Mexico. Hurricane wave conditions are mostly influenced by wind speed, storm size and forward speed of the storm. Wind speed and size translate into wave height using conventional fetch-limited wave growth behavior. Bigger but weaker storms may result in more extreme conditions than the smaller more intense storms. For instance, Isabel and Sandy resulted in significant wave heights of well above 40ft. Forward speed of the storm allows for waves traveling with that speed to be acted upon by wind longer, generating a "resonance" behavior. For instance, Juan hitting Halifax was a small storm with very high waves due to the "dynamic fetch" behavior. There is insufficient observational data to get reliable statistics for changes in wave design conditions, but such changes could be inferred from changes in hurricane climate, assuming that such changes address the three main hurricane parameters determining hurricane wave conditions. These estimates can only be as good as the estimates in the changes in the hurricane climate.

1.c: What affects do you anticipate on ocean currents?

A: The ocean current question, has not been answered yet, and should be posed to the GFDL (Geophysical Fluid Dynamics Laboratory).

2. Is it possible to get a cumulative distribution table or curve for future precipitation at a specific location? Why or why not? For example, could I obtain today the cumulative distribution for November through January precipitation at a local Dam location? Also, it would be useful to compare the forecasted CDF (Cumulative Distribution Function) with the historic CDF. (Lead: Tom Karl- Ken Kunkel)

A: There are at least two statistically-downscaled data sets that could be used for this purpose. Both of these are at a 1/8 degree latitude by 1/8 degree longitude spatial resolution and daily time resolution. One of these uses a technique known as Asynchronous Regional Regression Model [ARRM, Stoner, A. M. K., Hayhoe, K., Yang, X. and Wuebbles, D. J. (2012), An asynchronous regional regression model for statistical downscaling of daily climate variables. Int. J. Climatol. doi: 10.1002/joc.3603]. Data have been downscaled from 11 CMIP3 models for the A2, A1B, and B1 emissions scenarios for the period of 2001-2100. These data were produced for the U.S. Geological Survey.

The second data set uses a technique known as the Bias-Correction Constructed Analogs (BCCA) (Maurer and others, 2010). This method produces daily resolution time series of precipitation. The method preserves the actual sequences of weather that occur in GCM simulations. A group of collaborators produced a set of 53 projections through year 2100 from 15 separate CMIP3(Coupled Model Intercomparison Project) GCMs. Data and information are available at:

http://gdo-dcp.uc1lnl.org/downscaled_cmip_projections/dcpInterface.html#Welcome

Specifically, the BCCA projections are available for the periods of 1961-2000, 2046-2065, and 2081-2100.

1 Collaborators include: Climate Central, Lawrence Livermore National Laboratory, U.S. Bureau of Reclamation, Santa Clara University, Scripps Institution of Oceanography, U.S. Army Corps of Engineers, and the U.S. Geological Survey.
Both of these methods downscale data from daily GCM data and thus preserve the sequencing of weather in the global model. However, the limitations of GCM data must be recognized. There are biases in the simulation of precipitation in GCMs. While downscaling largely corrects these biases, it is not known how reliable such downscaling estimates are when examining the extremes of the distribution.

3. Can NOAA provide changing risk data and risk assessment processes to account for changing rather than solely historical risk? (Lead: Karl – Stephanie Herring, coordinating with other Project Leads)

A: The risk of impacts from the changing climate and extreme events depends on the extent of the changes and on the exposure and vulnerability of the relevant assets. Risk assessments take into account all three of these factors to determine risk for specific issues. NOAA provides both the risk data on the projected future changes and sector specific risk assessments.

NOAA’s climate data available for risk assessments:

NOAA provides foundational science about climate variability and change, and works with partners who have sector-specific exposure and vulnerability information to develop tailored risk assessments:

a. Providing trends: NOAA’s National Climatic Data Center in Asheville, NC is the steward of the nation’s historical climate record. But in addition to being the world's largest climate data archive, they are actively doing research to understand what trends we are seeing in the climate system, and what this means for the future climate we will experience. In addition, they have visualization tools that allow you to see how the climate is changing in spatial scales relevant to you. (http://www.ncdc.noaa.gov/)

b. Providing predictions of future changes: NOAA produces predictions of the future climate ranging from 2 weeks out to centuries that are used in determining future risks. For example, NOAA’s Climate Prediction Center (http://www.cpc.ncep.noaa.gov/) in College Park, MD, regularly produces outlooks from 6-10 days out to one year for key climate variables including temperature, precipitation, drought, and other hazards. They also provide regular updates on ENSO conditions, with El Nino and La Nina forecasts. Another important product is their ocean climate services with updates and outlooks on global ocean conditions. NOAA’s Geophysical Fluid Dynamics Laboratory, in Princeton, NJ (http://www.gfdl.noaa.gov/) is providing longer term projections of future climate scenarios from decades to centuries. All of these are designed to provide information that can be applied to sector and issue specific risk assessments.

c. Example of use in transportation: The Department of Transportation recently completed a report on the potential impacts of the changing climate on public transportation infrastructure systems. They used predictions of the future climate, ranges of possible temperature and precipitation extremes, and statistical trend analysis produced by NOAA to develop their report. (http://www.fta.dot.gov/documents/FTA_0001_-_Flooded_Bus_Barns_and_Buckled_Rails.pdf)

 d. NOAA is working with the National Academy of Sciences and other agencies to advance an open-source disaster risk modeling framework. This is a broad-based approach to risk modeling, from event modeling through impact modeling.

NOAA’s sector-specific risk assessments:

NOAA also produces risk assessments for key sectors and issues that are within our mission responsibilities including: Water Resources, Coastal Inundation, Weather and Climate Extremes, and Marine Ecosystems.

a. Example of Coastal Inundation risk assessment: NOAA’s Coastal Services Center in Charleston, SC works directly with coastal communities and coastal managers to take the best available science about the future climate, create user friendly tools so that information can be readily applied in decision making, and
develops risk assessments for coastal areas. By doing so, they work to promote resilience by reducing exposure and vulnerability to extremes. “We certainly don’t have all the answers. But we do have a commitment to provide tools that help each community find the answers that work best for its situation.”
http://www.csc.noaa.gov/climate/

4. Can NOAA provide new modeling tools to provide both analysts and decision makers with accessible, reliable, and localized understanding of risks from all hazards under a changing climate?
(Lead: Rick Rosen – Don Anderson)

A: The National Academy of Sciences (NAS) is engaged in a discussion regarding development of a North American Risk Model (NARM) developed with a public-private-academic partnership to assist in managing risk associated with Extreme Events. However, the requisite fundamental scientific understanding of how global change effects at large scales impact localized events is not currently available. Weather events, e.g. hurricane landfall time/location and intensity prediction is approaching a scientifically mature state. But how risk can be assessed regarding a climate change impact on recurrence regarding number and particularly location is not possible. Currently the only measure of useful predictability for risk analysis is that associated with recurrence/number in the context of natural variability, e.g. El Nino-hurricanes/typhoons. And that understanding is based on a combination of the study of historical events and maturing hurricane systems modeling/observations research.

5. Is NOAA developing new methodologies for benefit/cost analysis to account for future risk?
(Lead: Tom Karl– Adam Smith, coordinating with Linwood Pendleton and others)

A: NOAA’s approach to developing cost-benefit analysis methodologies is often focused on quantifying the value of particular NOAA products, rather than generalized methodologies. For example, one NOAA-sponsored study examined the impact of weather variability on U.S. Gross Domestic Product using econometric modeling of historical weather and economic data. Another study examined how NOAA’s next generation GOES-R satellites will use enhanced instrumentation, which will improve existing satellite data products and result in economic benefits such as more accurate energy demand and water demand forecasting.

6. What is the 10-yr trend for major wind, precipitation, and hail events in the major cities of the US? Using GIS, can these event trends be depicted geographically? (Lead: Tom Karl – Derek Arndt and Russell Vose)

A: The following answer addresses questions 6-8 as they are related and complementary.
NOAA operationally monitors trends in bias-adjusted temperatures across the United States and depicts them graphically using GIS (Geographic information System) (Fig. 1). In general, average annual temperature increased in most major U.S. cities from 1981-2010 and 1991-2010, with only a few areas experiencing small decreases (e.g., parts of the Northwest). In contrast, decreases in temperature were fairly widespread from 2001-2010, except for parts of the Northeast and the South, which experienced increases. Trends from 2001-2010 should be viewed with some skepticism, however, as it is difficult to reliably estimate changes over such a short period.
NOAA operationally monitors trends in precipitation as well (Fig. 2), though the patterns are often less coherent than for temperature. Very generally, average annual precipitation increased in the northern and eastern parts of the nation from 1981-2010 and 1991-2010, with decreases in the southern and western parts of the nation (and to some extent in Alaska and Hawaii as well). From 2001-2010, increases in precipitation were evident in most areas except for the Southeast, southern Alaska, and Hawaii, which generally experienced decreases. Again, trends from 2001-2010 should be viewed with caution.
NOAA does not operationally monitor trends in wind at present, but several studies have addressed such changes over the past several decades, and the evidence at present is inconclusive. The most comprehensive analysis to date (Pryor et al., 2009) is illustrative in this regard. Focusing on trends since the 1970s, this study noted that the in situ record and the
reanalysis record exhibited opposite trends (Fig. 3). In particular, the in situ record clearly depicted decreases in average wind speed nationwide and larger decreases in the eastern half of the nation. In contrast, atmospheric reanalysis products depicted no national-scale decrease at all, and some areas clearly contained increases.

NOAA does not operationally monitor trends in humidity at present, but several studies suggest there have been significant changes over the past several decades. For example, Willett et al. (2012) found increases in specific humidity over most of the United States from 1973-2011, with decreases in the Southwest and the extreme Southeast (i.e., Florida and coastal Georgia). Brown and DeGaetano (2012) noted increases in dewpoints in the northern and eastern parts of the nation since 1980, with some decreases in the southern and western regions. Both studies accounted for the numerous changes in observing practice that contaminate the humidity record.

Improvements to, and changes in, the methods and practices forecasting, observing, defining and verifying large hail have introduced inconsistencies into the hail record, which is generally inconclusive on the national scale (Kunkel, et al., 2012). Changnon and Changnon (2000) identified regional changes in hail frequency from reports made at official surface observing sites. With the change to automated surface observing sites in the 1990s, the number of hail reports at those locations dropped dramatically because of the loss of human observers at the sites. As a result, comparisons to the Changnon and Changnon work cannot be continued, although Changnon et al. (2001) have attempted to use insurance loss records as a proxy for hail occurrence. Several state and national hail diameter records have been verified in recent years by NOAA’s State and National Climate Extremes Committees, but this information is not sufficient to imply a trend.

NOAA provides several sources of data relevant to this question, including:

- Storm Events Database and Severe Weather Data Inventory (http://www.ncdc.noaa.gov/severe-weather)

Figure 1. Trends in annual temperature for 1981-2010, 1991-2010, and 2001-2010 for major U.S. cities. Trends were computed using data that had been adjusted for historical changes in station location, temperature instrumentation, observing practice, and land use.

Figure 2. Trends in annual precipitation for 1981-2010, 1991-2010, and 2001-2010 for major U.S. cities.
**Figure 3.** Trends of 50th percentile 10-m wind speed at the annual time scale in two station-based data sets from NCDC (6241 and 3505) and two atmospheric reanalyses (ERA-40 and NARR). In each frame dot size scales linearly with the size of the trend; red depicts increases, and blue depicts decreases. Data set 6241 is the Enhance hourly wind station data for the Continental U.S. Data set 3505 is the Integrated Surface Database.

**References**


7. Can historic hail diameter be determined for past events over the last 10 years and plotted using GIS so trends can be determined on a major city basis? Similarly, can this be done with wind speed and precipitation amount? (Lead: Tom Karl – Derek Arndt and Russell Vose)
A: The answer to Question 6 addresses these questions.

8. What is the 10-yr, 20-yr and 30-yr trend for temperatures, wind, precipitation (including humidity), and hail events in major cities of the US? (Lead: Tom Karl – Derek Arndt and Russell Vose)

A: The answer to Question 6 addresses these questions.

9. What is the predicted severity of the effects of trends, changes, episodes, and events on people regarding discomfort, relocation, loss of potable water, access to energy grid, etc.? (Lead: Tom Karl - Stephanie Herring)

A: Extreme weather and climate events, interacting with exposed and vulnerable human and natural systems, can lead to disasters.

Impacts from climate variability and change will be determined by the severity of the changes, exposure and vulnerability (IPCC Special Report on Extremes). NOAA plays a critical role in helping people understand future changes and variability in climate so they can make cost effective decisions that may limit their exposure (e.g., moving major infrastructure away from the coasts in anticipation of sea level change), and reduce their vulnerability in the face of change (e.g., designing city water infrastructure to accommodate increased precipitation extremes). The predicted severity of the effects from climate variability and change will depend on the choices that businesses and governments make. The best choices will likely vary from sector to sector and from community to community. The ability to mitigate impacts and the range of choices available may also vary greatly based on geography and sectors of the economy.

Current understanding of trends and future climate scenarios, along with regional and sectoral impacts, are captured in the report “Global Climate Change Impacts in the United States” produced in 2009. A new National Climate Assessment is scheduled to be released in 2013 and will provide comprehensive updates. The U.S. Global Change Research Program has produced 21 individual assessments (known as the Synthesis and Assessment Products, or “SAPs”) to look in depth at the impacts of climate change on specific sectors including transportation, agriculture, energy and water. Of particular relevance to question 9 is SAP 3.3, “Weather and Climate Extremes in a Changing Climate”. For more information on current and future national assessments, please visit www.globalchange.gov. NOAA also produces specific impact assessments on key issues relevant to our mission areas, including coastal inundation, fisheries, water resources, and extreme weather and climate events. Please visit www.climate.gov for additional information on the range of NOAA’s products and services.

There are numerous examples of how many sectors and regions are already using climate change and variability information from NOAA to inform their risk management decisions. For example, in 2011 NOAA’s seasonal predictions from the Climate Prediction Center indicated extreme rainfall was likely in Hawaii, prompting the construction landfill provider PVT Land Company to upgrade their storm water systems. When the predicted wet weather hit, PVT was prepared and did not lose a single day of their operations, in contrast to another local construction landfill that was shut down for significant periods of the wet season due to improper drainage. PVT estimated their avoided losses of $600,000 in gross sales, $100,000 in lost salaries, and a potential $300,000 to $600,000 in damage to roads and landfill.

To help prepare for the climate of the future, NOAA’s National Climatic Data Center in Asheville, NC, monitors how what is “normal” has in fact been changing over time. By regularly updating climate normals for precipitation and temperature, major infrastructure decisions can be designed for the climate of the future. For example, Bureau of Land Management recently updated all of their dam infrastructure requirements to account for anticipated precipitation extremes. The American Association of Home Builders also uses the data from the Asheville Data Center to update their air freezing index across the United States, which impacts building codes in communities nationwide.
10. Our firm assists public and private clients in investments in various types of infrastructure planning and design. Risk to existing infrastructure and planning and design of future infrastructure consists of sizing and operations under projected design event. These events have typically been defined under stationary climate assumptions at various exceedance or probability assumptions (e.g. 100-year 24-hour storm). How is NOAA making projections of changes to historical extreme events available for such planning? How are sub-daily precipitation events being evaluated from General Circulation Model scales to site-specific conditions? And under which types of regional climates or meteorological conditions is there confidence (or lack thereof) of the current ability to project changes in these extreme events? (Lead: Rick Rosen – Tom Peterson, Randy Dole, Marty Hoerling, and Chris Miller)

A: Probabilistic estimates of rainfall intensities for a range of durations (5 minutes to 24 hours) for return periods, or recurrence intervals, of 20, 50 and 100 years have been used by civil engineers for designs of transportation related infrastructure such as road culverts, storm water drainage systems, rail and roadbed design. Since 2003 NOAA/NWS/OHD (Office of Hydrologic Development) has been updating precipitation frequency estimates as volumes of NOAA Atlas 14. While their technique uses a longer period of record than earlier estimates, and thereby allows more confidence in the projections of rainfall frequency estimates, the technique does not incorporate projections of climate change. Nonetheless, the analyses being conducted now provide better estimates on which to base design decisions and implicitly reflect any climate change that might have occurred between the older and newer estimates. Completed and ongoing analyses are summarized at http://www.nws.noaa.gov/oh/hdsc/.

There have been statistically significant trends in the number of heavy precipitation events in some regions. It is likely that more of these regions have experienced increases than decreases, although there are strong regional and subregional variations in these trends. It is likely that the frequency of heavy precipitation or the proportion of total rainfall from heavy rainfalls will increase in the 21st century over many areas of the globe. This is particularly the case in the high latitudes and tropical regions, and in winter in the northern mid-latitudes. Heavy rainfalls associated with tropical cyclones are likely to increase with continued warming. There is medium confidence that, in some regions, increases in heavy precipitation will occur despite projected decreases in total precipitation in those regions. Based on a range of emissions scenarios (B1, A1B, A2), a 1-in-20 year annual maximum daily precipitation amount is likely to become a 1-in-5 to 1-in-15 year event by the end of the 21st century in many regions, and in most regions the higher emissions scenarios (A1B and A2) lead to a stronger projected decrease in return period.

Extreme precipitation episodes (heavy downpours) have become more frequent and intense and now account for a larger percentage of total precipitation. As sea surface temperature (SST) increases, the intensity (i.e., wind speeds of tropical storms) and the associated rainfall are likely to increase. For each 1 degree increase in SST, it has been estimated that core rainfall rates could increase between 6 and 18% and surface wind speeds 1 to 8%, but a more confident assessment requires additional study.

Projected precipitation events evaluated from General Circulation Model scales to site-specific conditions are discussed in more detail in the answers to Questions #1-2 (Climate Impacts on Water Resources) and Question #2 (Changes in Extremes of Weather and Climate).

11. Consistent data series on average and extreme events (events that might disrupt business operations – extreme precipitation etc.) so that current trends in climate measures can be established. In our case high resolution is not as important as consistency in reporting; e.g. the same drought indices are used through time and space. Our main use of the information is for inter-comparisons between locations (state, city) and changes in those comparisons through time. We can make use of similar projected data from climate modeling. (Lead: Tom Karl – Jeff Privette)

A: Besides providing rapid data for weather forecasting, NOAA has worked for decades to provide historically consistent “retrospective” data sets—a process sometimes called data set “homogenization” leading to uniform and consistent “climate data records” (CDRs). The primary goal is to eliminate data set artifacts caused by factors such as system degradation or
changes in instrumentation, observing practices, or observing environment that can occur through time. Historically, NOAA has been a world leader in producing multi-decadal CDRs from field measurements of the land, oceans and the atmosphere. In 2009, NOAA began a complementary program to develop and sustain CDRs from 35+ years of satellite remote sensing observations. The various CDRs are appropriate for deriving space and time averages, discerning trends, identifying extremes and establishing other characterizations (e.g., location-by-location probability distribution functions). NOAA currently provides many derived products, such as Surface Normals (site-level temporal averages) of air temperature and precipitation, and HURSAT (normalized basin-by-basin hurricane tracks and trends). In the near future, NOAA will provide additional derived products, and will release interactive software tools which allow users to “slice and dice” the CDRs as needed to characterize the climate over the times, areas, and variables they choose. Finally, NOAA is increasingly expanding the capability of NOAA’s CDRs to meet their eight non-functional requirements, namely that they are accessible, extensible, preserved, reproducible, sustainable, transparent, and continuously improved.

12. **Provision of biophysical data in a form that it is already, or can readily be compiled into spatial units consistent with socio-economic data collection; e.g. states, counties, census districts in the USA.**

(Lead: Tom Karl – Jeff Privette, Karsten Shein, and Russ Vose)

A: Due to the diverse stakeholder requirements that NOAA meets, we generally pursue the second option: provision of data in forms readily compiled into desired units. Specifically, rather than creating unique spatial aggregations for individual user communities, NOAA is adopting widely-used standards in data formats (e.g., NetCDF, KML, shapefiles), metadata (e.g., FGDC, ISO 19115(-2), CF convention), and data transfer protocols (e.g., OPeNDAP, OGC Web Services). This allows users to leverage the many commercial and open source software tools available for data access, manipulation and display, including Geographic Information Systems (GIS), which can generate the user-dicted spatial aggregations (i.e., states, counties) described in this question. NOAA stays engaged with leading data interoperability and standards organizations, as well as the NOAA user communities and technology groups, to ensure it remains abreast of data standards, trends and needs. We believe this solution most efficiently meets the needs of our users.

In addition, NOAA has been working diligently to provide biophysical data in forms that are readily accessible in forms that lend themselves to comparison with socio-economic data divisions. For example, NOAA’s Digital Coast effort combines such biophysical data as Benthic Cover, Sediment Profiles, and Land Cover with socio-economic data along the U.S. coasts. The NOAA National Ocean Service and the NOAA National Marine Fisheries Service maintain data on coastal and sea floor composition and boundaries, fish stocks, biodiversity, submerged aquatic vegetation, benthic geology, essential fish habitats, and other biophysical elements. As mentioned above, these data exist in formats (e.g., GIS shapefiles) and in adherence with metadata standards that facilitate their use consistent with socio-economic geographic divisions. NOAA also makes these data discoverable and accessible through metadata catalogs, such as the Coral Reef Information System (CORIS), and through data access/visualization tools such as the Digital Coast, Gulf of Mexico Data Atlas, Integrated Marine Protected Area Climate Tools, and others.

13. **We rely on NOAA for our source of national and international weather data. In an ideal world, we would like to be able to download historical, real-time, forecast, and outlook weather data in the same spatial and temporal scales. The scales can differ for the United States and the rest of the world. For example, the data for the U.S. could be at 5 km and an hourly time step, while data for the world could be 38 km and a daily time step. It would be the responsibility of NOAA to integrate the various weather data sources in order to create these standard data formats. Is such an approach possible? If so, how long would it take to create such standard data sets?**

(Lead: Jin Huang)

A: NOAA provides global Reanalysis datasets (such as the Climate Forecast System Reanalysis; 1979-present) that include historical and real time weather data at the same spatial and temporal resolution as numerical model forecasts. NOAA also maintains global datasets for specific variables, such as sea surface temperature and precipitation based entirely on observations (satellite and in-situ). Users are cautioned that spatially uniform gridded analyses should be used with care in areas of sparse observations.

To take advantage of rich observational data in some regions, such as the United States, NOAA also provides regional reanalyses. Both global and regional datasets are provided using standard data formats, such as GRIB2.

One possible solution to enhance access to these data sets is to integrate them under the GIS (Geographic Information...
System) framework. GIS integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information.

The temporal and spatial resolution of weather and climate forecast data varies, with weather forecasts (out to 7 days) and extended range forecasts (days 8-14) at higher spatial resolution, and monthly and seasonal forecasts at lower spatial resolution. Given the chaotic nature of the earth system, deterministic daily forecasts beyond 14 days are beyond the state-of-the-art, and probabilistic information is provided.

14. In order to evaluate non-weather models using forecast data as input, it is important to get historical forecast data sets, such as for CFSv2. Can we be given online access to historical forecast data sets? (Lead: Jin Huang)

A: The historical forecast data sets from CFSv2 (also called CFS Reforecasts) are available online (see http://www.ncdc.noaa.gov/model-data/climate-forecast-system-reanalysis-and-reforecast-cfsrr) and can be accessed by the general public.

15. Would it be possible to create future, global climatological data sets based on the predicted range in the Intergovernmental Panel on Climate Change (IPCC) climate-change scenarios? For example, could global climatological data sets be developed representing the most likely to least likely scenarios? These data sets would be useful as input into non-weather models. (Lead: Rick Rosen – Don Anderson)

A: A number of global climatological downscaled datasets exist. One in particular developed by Ed Mauer provides a well thought out approach to providing just such a suite of outcomes. Perhaps the best current website for information on, and access to, gridded datasets can be found at: http://cida.usgs.gov/climate/gdp/. This site requires the user to read and learn how to use the site, but has access to more datasets and with effort, has a lot of flexibility.

The Nature Conservancy website, http://www.climatewizard.org/, is very popular because it's very accessible and really just provides an overview of low, medium, high outcomes from the IPCC 4th assessment. And note that the site says: Data Source: Base climate projections downscaled by Maurer, et al. (2007) Santa Clara University.

16. When releasing weather data sets, could NOAA provide more detailed documentation on how they were created along with examples? Also, please provide the file naming conventions. (Lead: Jin Huang)

A: NOAA currently provides some documentation, including comments on model source codes. NOAA is continually working to improve documentation, including file naming conventions, etc.

17. Could a table be developed that lists all NOAA weather data sets and a point of contact (person) so that questions can be answered and help be given before acquisition? (Lead: Wayne Higgins)

A: Such an inventory is possible but has not (to our knowledge) been undertaken. NOAA has a wide range of weather (and climate) datasets. Information on many of these is found via the NOAA Web Page (www.noaa.gov), the NWS Web Page (www.weather.gov), and NOAA’s Climate Portal (www.climate.gov). Examples of available climate information products and climate data sets (many of which are applicable for studies of weather and weather-climate linkages) are included in the Handout provided at the NOAA-CIRUN Roundtable.

18. Can CPC adhere to NOAA’s GRIB2 data formatting so that there is one convention? (Lead: Jin Huang)

A: Yes, it is possible. Model generated data or model related fields are in GRIB2. However, CPC also produces data in many other formats based on customer needs. The current practice at CPC is to produce data using formats that meet the needs of the largest set of customers. Thus, in order to use a single convention (such as GRIB2), some homework is required by both data producers and data users to ensure that this format would meet the needs of customers.

19. In case of derivative variables, such as relative humidity, could the algorithms be published?
A: NCEP has documentation on its weather and climate models and related datasets. However, as discussed in Question 17, improvements are needed to make such documentation thorough, usable and accessible. Depending on model details, some algorithms are not published in the scientific literature. In these cases, NOAA should publish its source code with detailed comments imbedded.

20. Can NOAA develop real-time, integrated precipitation data sets that take advantage of different satellites? Can the lag time between collection, processing, and delivery be reduced to a one or two days?

A: Yes, NOAA/CPC has already developed a technique, called the CPC Morphing technique that integrates precipitation information from ALL available geostationary and low earth orbiting satellites, yielding high-resolution quasi global precipitation estimates. The CMORPH satellite estimates are produced on an 8km x 8km grid over the globe from 60S to 60N, covering the period from January 1, 1998 to present, and updated on a real-time basis with a delay of 3 hours. Contact: Dr. Pingping Xie (Pingping.Xie@noaa.gov)

CMORPH shows consistently superior performance when compared to similar products (e.g. the TRMM products of NASA). Additional improvements to CMORPH are underway: a) to extend coverage to the entire globe from pole to pole, b) to improve the estimates of snowfall, and c) to generate a regional version of CMORPH covering North America with a higher spatial / temporal resolution (4km x 4km; 15-min) and further reduced latency (about one hour).
Appendix 4: Status of NOAA Products and Services

Outline:

- NOAA Participants in Roundtable
- Demand for Climate Services
- NOAA Climate Strategy
- NOAA Climate Information and Data Products
  - Current
  - Future

29 November 2012
NOAA Participants

Thomas R. Karl, Director, National Climatic Data Center
Richard R. Rosen, Acting Director, Climate Program Office
Jin Huang, Director, NOAA Climate Test Bed
Margaret Davidson, Director, Coastal Services Center
Wayne Hefflin, Director, Climate Prediction Center
Stephanie O. Harring, Project Lead, Weather and Climate Extremes, National Climatic Data Center
Roger Pulwarty, NODS Lead, Climate Program Office
Roger Swift, Climate Orange Coordinator, NOAA Fisheries Service
Emily Becker, Research Scientist, Climate Prediction Center

The Rising Demand for Climate Services

- Commerce
- Coasts
- Recreation
- Ecosystems
- Hydropower
- Farming
- Health
- Private Sector
NCDC Example Products

Example Climate Information Products
- Tools
  - Climate Data Online - OSI-based map interface
  - Weather and Climate Viewer
  - Climate at a Glance (U.S. and Global)
- Climate of the U.S.
  - U.S. Climate Normals
  - U.S. Wind Climatology
  - Climate Atlas of the U.S.
- Monitoring
  - Monthly Climate Highlights (U.S. and World)
  - U.S. Billion-Ton Disaster
  - Drought Portal (U.S., North American, Global)
- Extreme Events
  - U.S. Records
  - Climate Indices Index, Regional Snowfall Index
  - Annual SANS Explaining Science Report
- Statistical Information
  - Temperature, Precipitation & Drought Monitorings, Rankings, Maps
- Regional & Sectoral
  - National Energy Demand Temperature Index
  - National Climate Indices
- Assessments
  - International (IPCC)
  - National Climate Assessment
  - Annual SANS State of the Climate Report

Example Climate Data Products
- Climate Data Records
- Surface-Based Station Data
  - Local U.S. Climatological Data
  - Global Historical Climate Network-Daily
  - U.S. Climate Reference Network
  - National Solar Radiation Database
- Satellite Data
  - Geostationary, Polar-orbiting
- Radar Data
  - NEXRAD Dual-Polarized
- Model Data
  - Reanalysis, Numerical Weather Prediction, Climate Prediction (GCMs)
- Weather Balloon Data
  - Integrated Global Radiosonde Archive
- Marine/Ocean Data
  - Multiple global data sets
- Paleoclimate Data
  - Derived from multiple sources
- Severe Weather
  - Storm Events Database, International Best Hurricane Track Archive for Climate Stewardship

Coastal Services Center (CSC) Top Products and Services

Example Climate Information Products
- Tools
  - Sea Level Rise and Coastal Flood Frequency Viewer
  - Coastal County Snapshots
  - Census Visualization Tool
  - Habitat Priority Planner
- Training and Technical Assistance
  - Coastal Adaptation for Coastal Communities
  - Coastal Inundation Mapping
  - Planning for Climate Change
  - Roadmap for Adapting to Coastal Risk
  - Coastal Community Planning and Development
- Publications
  - Marshes on the Move
  - Incorporating Sea Level Change Scenarios at the Local Level
  - Coastal Inundation Mapping Guidebook
  - Understanding Risk Behavior
  - Local Strategies for Addressing Climate Change

Example Climate Data Products
- Elevation Data
  - Topographic and Bathymetric Data Inventory
  - Coastal Lidar Data
- Land Cover Data
  - CCAP High Resolution and Regional Data
- Data and Information Suits
  - Coastal Climate Adaptation Website
  - Coastal Inundation Toolkit

Point of Contact: Margaret Davidson
For more information:
http://csc.noaa.gov/
http://csc.noaa.gov/digitalcoast/
1. Monitoring and Assessment of Climate Impacts on Marine Ecosystems
   Regional long-term monitoring of ocean physical, chemical and biological conditions for fisheries management, protected species recovery, and habitat conservation.

2. Increased Understanding of Climate Impacts on Marine Ecosystems
   Regional research programs to understand impacts of climate variability and change on marine ecosystems, managed resources, habitats and dependent communities.

3. Projections of Climate-related Impacts on Marine Ecosystems and Resource-Dependent Communities
   Research and modeling to understand future climate-related impacts on marine ecosystems, managed resources and habitats.

4. Management Actions to Reduce Impacts and Increase Resilience
   Management actions (e.g., fishery management plans, protected species recovery plans, habitat conservation efforts) to reduce impacts, increase resilience and sustain marine resources and the communities that depend on them in a changing climate.

Web site: www.nmfs.noaa.gov
Point of Contact: Roger Griffis (Roger.Griffis@noaa.gov)

Climate Program Office (CPO)
Top Products and Services

1. Observations and Monitoring: Develops and sustains global in situ climate observing systems; Supports >50% of the sustained Global Ocean Observing System; Supports projects that produce datasets essential to international and national climate assessments; Annual State of the Climate Report

2. Understanding and Modeling: Over 700 published papers/yr citing CPO support, contributing to growing understanding of climate variability and change; Improved operational systems through CPO-supported research; Field campaigns

3. Informing Decisions: National Integrated Drought Information System (Drought.gov & pilot drought early warning systems); Regional Integrated Sciences and Assessments; Climate training workshops and reports directed to needs of resource managers; Fund National Research Council reports, including America's Climate Choices; Provide scientific input, coordination, funding, and sustained engagement for the National Climate Assessment

4. Program Development: Implementation plan for all NOAA climate activities; 176 NOAA Climate and Global Change Postdoctoral Fellows, 35 AMS Graduate Fellows, and 9 Post Docs Applying Climate Expertise (PACE) since inception of programs; New programs (e.g., National Climate Predictions and Projections platform, Deep Argo, Coastal and Ocean Climate Applications)

Web Page: www.cpo.noaa.gov
Point of Contact: Rick Rosen (rick.rosen@noaa.gov)
5. NOAA Climate.gov Portal: A public-friendly point-of-entry into NOAA's and partners' diverse offerings of climate data and information. We promote public understanding of climate science and the current state of the climate system to enhance public decision-making.

We offer four audience-focused sections with four objectives: ClimateWatch Magazine to inform and 'educate' the climate-interested public; Data & Services to simplify discoverability and access to data products; Education to help teachers integrate climate science into learning venues; and Understanding Climate to provide policy leaders and decision makers with authoritative information resources to help them understand & manage climate-related risks.
Examples of Future Climate Products by Societal Challenge

Where are we headed in the next 1-2 years?

**Climate Impacts on Water Resources**

- Improve forecast reliability for droughts and floods (onset, duration, severity) recognizing the influence of decadal and longer-term forcings.
- Diagnose the role of precipitation events and land surface conditions in amplifying or reducing the severity of drought and flood impacts.
- Develop timely, accessible communications tools and impacts assessments to support water, food, energy security, and disaster risk reduction.
- Employ existing cross-sectoral (interagency, state, private, and tribal) partnerships to improve coordination for prioritizing and advancing monitoring, forecasts and impacts assessment from watersheds to coast.

Examples of Future Climate Products by Societal Challenge

Where are we headed in the next 1-2 years?

**Coasts and Climate Resilience**

- Measure the total water level from all sources.
- Easily accessible total water level-related information.
- Broaden understanding of climate and coastal inundation-related hazards vulnerability and summaries of the current state of knowledge.
- Predict or forecast total water level from all sources, including local to regional differences in the rate of change of total water level from coastal inundation.
- Create products that allow decision makers to visualize the potential impacts from coastal inundation across time scales.
**Examples of Future Climate Products by Societal Challenge**

**Where are we headed in the next 1-2 years?**

**Changes in Extremes of Weather & Climate**

- Prioritize user needs against NOAA’s expertise and identify focused improvements in science-based decision support products and services.
- Develop visualizations and data products that convey changes in weather and climate extremes, and a monitoring strategy that ensures continuity of observations for key extremes needed to inform risk management.
- Deliver improved predictions and projections services by establishing reliable estimates of confidence, ensuring access for use in risk modeling frameworks, and improving skill by advancing understanding of weather and climate extremes.
- Enhance access to, and understanding of, credible and current state of knowledge about extreme weather and climate events for key audiences.

**Sustainability of Marine Ecosystems**

- Regional information on past changes in climate and ocean conditions.
- Regional assessments of past climate-related impacts on living marine resources (What has changed?).
- Seasonal forecasts of regional climate and ocean conditions (Early warnings, outlooks etc...).
- Coupled projections of future climate - ocean - marine resource conditions (decadal to multi-decadal scales).
- Assessments of risks and impacts for use in management decisions (fisheries, protected species, protected areas etc.).
Appendix 5: The NOAA Climate Prediction Center

CPC Mission

We deliver climate prediction, monitoring, and diagnostic products for timescales from weeks to years to the Nation and the global community for the protection of life and property and the enhancement of the economy.

Operational Requirements:
- Deliver National outlook products: temperature, precipitation, drought, hurricanes, ...
- Span weeks, months, seasons, years
- Embrace collaborative forecasting with other NCEP Service Centers, NOAA line offices, other agencies
- Ensure real-time, on-time, all the time access (since ’79)
CPC Prediction and Monitoring Products

Official Outlooks focused on week-2, monthly, seasonal
- Precipitation & Temperature Outlooks
- Hazards Outlooks (US, Global Tropics)
- Seasonal Drought Outlook
- Seasonal Hurricane Outlooks (Atlantic and Eastern Pacific)
- El Nino / La Nina Prediction

Real-time and historic monitoring of atmosphere, ocean, land surface conditions
- Daily and monthly data, time series, and spatial maps
- Primary modes of climate variability (ENSO, MJO, NAO, PNA, AO...)
- Storm Tracks and Blocking
- Monsoons
- Precipitation and Surface Temperature
- Drought (US, North America; NIDIS)

CPC Climate Diagnostic Products

Synthesis of current weather and climate information and forecasts; issued on a routine basis
- Climate Diagnostics Bulletin (monthly, web)
- ENSO Diagnostics Discussion (monthly, PDF and WORD)
- Weekly ENSO / MJO / Monsoon / Ocean updates (.ppt, PDF, web)
- Seasonal Climate Summaries (web)
- Special Climate Assessments (extreme events, web)
- Annual Climate Assessment (multi-agency; published in the AMS Bulletin)
NCEP Supports the NOAA Seamless Suite of Climate, Weather, and Ocean Products

**Organization:** Central component of NOAA National Weather Service

**Mission:** NCEP delivers science-based environmental predictions to the nation and the global community. We collaborate with partners and customers to produce **reliable, timely, and accurate** analyses, guidance, forecasts, and warnings for the protection of life and property and the enhancement of the national economy.

**Vision:** The Nation’s trusted source, first alert, and preferred partner for environmental prediction services

---

**NOAA Forecast Products**

**Spanning Climate and Weather**

- Climate Outlooks
- Climate Predictions
- Weather Forecasts
- Warnings

**Forecast Lead Time**

- Decadal
- Forecast Uncertainty
- CPC
- Climate-Weather Linkage

**Impact-Based Decision Support**

- Recovery
- Response
- Preparation
Test Beds and the R2O Challenges
Service – Science Linkage with the Broad Community:
Accelerating the R2O Transition Process

- EMC  WRF Developmental Test Center,
  Joint Center for Satellite Data Assimilation
- CPC  Climate Test Bed
- NHC  Joint Hurricane Test Bed
- HPC  Hydrometeorological Test Bed
- SPC  Hazardous Weather Test Bed with NSSL
- SWPC Space Weather Prediction Test Bed with AFWA
- AWC  Aviation Weather Test Bed
- OPC  IOOS Supported Test Bed (in discussion with NOS/IOOS)

International Desks

➢ African Desk
➢ Monsoon Training Desk
➢ Tropical and South American Desks

Activities

- Training and Education
- Partnerships
- Products
  - Famine Early Warning System
  - Hazards Outlooks (Africa, global tropics)
  - Tropical Cyclone Monitoring
Climate Prediction Center Web Site

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Climate Modeling and Prediction Advances

Climate Forecast System
NOAA’s first dynamic, fully-coupled operational climate forecast model
- CFSv2 operational (Mar 2011)
- CFSv3 strategy with community (2012+)

These advances have improved forecast skill

Climate Test Bed
Science Priorities:
- Climate Forecast System improvements
- Multi Model Ensembles
- Climate forecast products

U.S. Seasonal Temperature - Skill

Climate Test Bed spin up
IMME, NMME Implemented

54
Multi-Model Ensembles (MME)

- **Operational International MME** (EUROSIP + CFS)

**Current Products**
Monthly and seasonal mean sea surface temperature, precipitation and surface temperature for North America and for global domains, and a plume diagram for Nino3.4 sea surface temperature.

**Future Products**
Probabilistic expressions, and skill maps for SST, precip and surface temp followed by new 'requests', such as wind-shear in support of the Atlantic Hurricane Seasonal Outlooks.

Leverage the Climate Enterprise

Cooperate and collaborate with the broader climate enterprise
- Seek to better understand the broader climate enterprise
- Identify data and services that can enhance public value when delivered through enterprise partners
- Ex: CFSv2 forecasts thru private service provider
Climate Prediction Center

- Delivers a suite of “operational” climate prediction, monitoring, and assessment products
- Accelerates advances in climate prediction and fills gaps in the “seamless suite” of climate products
- Works across NOAA and with other organizations on expanded responsibilities for climate; interdisciplinary approaches are the key to success
- Plays a unique and critical role in NOAA climate services

More Information:
- Contact Wayne.Higgins@noaa.gov
- CPC Web Site: www.cpc.ncep.noaa.gov
Appendix 6: The NOAA Climatic Data Center

National Climatic Data Center
Deep Dive

November, 2012
Acquire and Archive Climate Data From U.S. and International Sources

Data spans stone-age to space-age... and across the globe

IBTrACS (International Best Track Archive for Climate Stewardship) 1842-2011

Managing and Operating the U.S. Climate Reference Network

U.S. Climate Reference Network (USCRN) Stations

Comparison of Adjusted Mean Annual Temperature

Reference Networks offer climate-quality information for assessing long-term climate change and variability

Climate Reference Network Site: Montrose, Colorado
Serving and Preserving the Nation's Climate Data
Demand Continues to Grow

Users download over 1,900 Terabytes/year = 6 Million Kindle Books/day

NCDC provides safe storage of 9,900 Petabytes = 11.5 Billion Kindle Books

Assemble Data into Easy-to-Use, Long-Term Datasets: Climate Products

Climate Data Records provide robust information for scientific applications based on the Nation's investment in observation systems

NCDC released the 1981-2010 statistical Climate Normals for 9,800 stations
Who Is Using Our Weather and Climate Data?

For past 12 months through September 2012
- Calls: 15,588
- E-Mails: 7,056
- Faxes: 223
- Letters: 236

Assess the Earth’s Climate: Climate Monitoring
A Few Examples

- Host and co-produce the U.S. Drought Portal
- Produce weekly, monthly, seasonal, and annual climate analyses
- Produce assessments of snowfall across the U.S.
- Analyze variations and changes in global surface temperature
Assess the Earth’s Climate: International, National, Annual Assessments

International Assessments
- 3 NCDC lead authors and review editors on Fourth Assessment Report
- 2 NCDC lead authors on Fifth Assessment Report
- 2 NCDC lead authors on Special Report on Extremes

National Assessments
- NCDC provides leadership for all National Climate Assessments
- NCDC hosts National Assessment’s technical support unit

Annual Assessments
- NCDC coordinates 376 authors from 48 countries
- Covered by all major news networks, 6000+ media links every year

Over 50 peer-reviewed papers every year

For More Information

Visit www.ncdc.noaa.gov
Appendix 7: NOAA’s Societal Challenges Needs Assessment – Background

Purpose

- Initiate the process to establish the formal mechanism for determining priority decision-maker customer needs associated with each societal challenge.
- Educate Climate Service board regarding needs assessments as a process for decision-maker needs, which will inform the organizational planning (i.e., shift from science push to decision-maker pull)

FY11 Deliverable

- Deliver audience analysis and needs assessment reports

Societal Challenges and Leads

- Sustainability of Marine Ecosystems – Margarita Gregg (Roger G. & Kenric O.)
- Coasts & Climate Resilience – Paul Scholz
- Climate Impacts on Water Resources – Roger Pulwarty
- Changes in Extremes of Weather and Climate – Wayne Higgins
- Leads are responsible for/to:
  - Identify FY11 deliverables (for AOP) {NOTE: See next steps for proposed list.}
  - Coordinate the team of people & execution
  - Needs assessment process
  - Develop storyline for needs assessment and then the societal challenge
  - Leverage NGSP objectives work and previous work done by various partners in each challenge area

Key Definitions

- Goal of a needs assessment: to conduct a systematic investigation of an audience(s) to identify aspects of individual knowledge, skill, interest, attitude and/or abilities relevant to a particular issue, organizational goal, or objective.
- Needs are gaps – the space between what currently exists and what should exist.

Collecting Data for Needs Assessments

Seven Basic Methods

**Observation** — watch and record behavior
- Pro: inexpensive, doesn’t interrupt work
- Con: observer’s presence may alter behavior

**Interviews**—ask questions directly to a person, either face-to-face or via technology
- Pro: allows for multiple perspectives and elaboration
- Con: can be very time intensive

**Focus Groups**—ask questions of a representative group of people
- Pro: fosters brainstorming, provides wide range of views
- Con: participants may influence each other, difficult to analyze

**Oral Survey**—interview using set questions and answer choices
- Pro: interviewer can clarify questions, easy to analyze
- Con: no free expression, interviewer may influence participants

**Written Survey**—ask participants to complete written questionnaires
- Pro: easy to distribute widely and to analyze, unbiased
- Con: information can be interpreted differently

**Existing Data**—analyze existing reports, work samples, evaluations, and other data
- Pro: often less time consuming
- Con: data can be out-of-date or incomplete

**Test**—assess particular knowledge or skill level using an exam
- Pro: easy to quantify results and note deficiencies
- Con: hard to validate results, people don’t like tests
Wants are solutions – a proposed means to filling the gap.

Requirements analysis – done in preparation for development of new products and services after determining needs and wants

**Needs Assessment Stages**

1. Planning – establish teams to finalize audience, purpose, goals, and boundary conditions (scope, scale, and complexity) for each societal challenge, as well as the actual methods to be used.
2. Needs Assessment Data Collection – number of options for data collection needs to consider resources for collecting, analyzing, and managing the data (see pullout box for most common methods used). Once you have your methods then:
   - What is the sample size of your audience to be used
   - Design and test your collection method
   - Gather and record your data
3. Data Analysis – conduct the analysis, store the data, write the report
4. Application – this is where the detailed requirements documentation gets developed and delivered to feed into the product and service development and delivery

---

2 (For a complete on-line training module related to needs assessments go to – http://www.csc.noaa.gov/needs/home.html)
Appendix 8: NOAA’s Coastal Sea-Level Change Societal Challenge Needs Assessment Report

NOTE: Double click on document on the next page