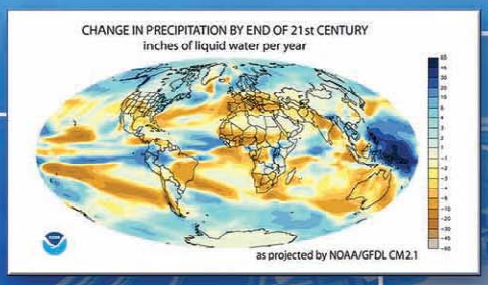
Integrated Modeling to Characterize Climate Change Impacts and Support Decision Making

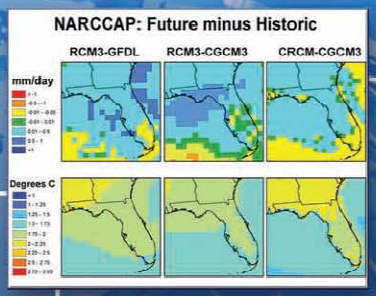
Participants Guide

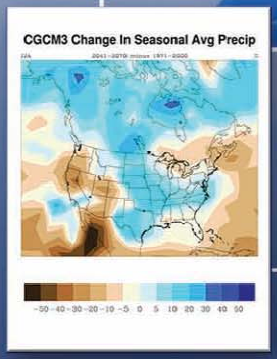
February 1 - 2, 2011 | Atlanta, GA

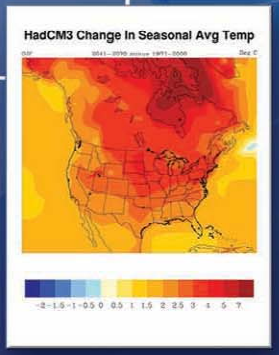


"We envision a resilient, healthy, and prosperous Nation in the face of a changing climate."

- Progress Report of the Interagency Climate Change Adaptation Task Force, October 5, 2010







EPA
United States
Environmental Protection
Agency

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About EPA's Council for Regulatory Environmental Modeling (CREM):
Given the crucial role that models play in informing regulatory decision making, the EPA established the Council for Regulatory Environmental Modeling (CREM) in 2000 in an effort to improve the quality, consistency and transparency of the models for environmental decision making. The CREM is a cross-Agency council of senior managers charged with developing practices to ensure that EPA's use of environmental models is consistent and defensible. http://www.epa.gov/crem

About the CREM's Integrated Modeling Program:
The CREM Integrated Modeling Program includes a set of activities that support CREM Strategic Goal 4 (Enhancing Integrated Modeling for Environmental Decision Making: to bridge disciplines and foster a more integrated and joined up thinking approach to modeling in environmental management, and to advance integrated modeling science and technology). These activities will help to facilitate the development of a strong integrated modeling capacity that supports environmental decision making at EPA.

The workshop on **Integrated Modeling to Characterize Climate Change Impacts and Support Decision Making** is the second of a series of symposia and workshops in the CREM Integrated Modeling Forum. The Integrated Modeling Forum seeks to create a cross-Agency forum for coordination and exchange of information on modeling activities related to high priority science and technology issues which would benefit from a systems analysis and integrated modeling approach.

Integrated modeling for integrated environmental decision making is a system analysis-based approach that includes a set of multi-disciplinary, interdependent, science based components (models, data, assessments, polls, expert elicitation) that together form the basis for constructing a modeling system capable of simulating environmental systems relevant to a well specified problem statement.

Letter to Participants

U.S. ENVIRONMENTAL PROTECTION AGENCY

WASHINGTON, DC 20460

"Much of the nation's experience to date in managing and protecting its people, resources, and infrastructure is based on the historic record of climate variability during a period of relatively stable climate. Adaptation to climate change calls for a new paradigm – one that considers a range of possible future climate conditions and associated impacts, some well outside the realm of past experience."

"Adaptation … requires actions from many decision-makers in federal, state, tribal, and local governments."

"Current efforts are hampered by a lack of solid information about the benefits, costs, and effectiveness of various adaptation options, by uncertainty about future climate impacts at a scale necessary for decision-making, and by a lack of coordination."

---National Academy of Sciences, Adapting to the Impacts of Climate Change

Dear Workshop Participants:

Welcome and thank you for your interest in and enthusiasm for the upcoming workshop on **Integrated Modeling to Characterize Climate Change Impacts and Support Decision Making**! The US Environmental Protection Agency (EPA) is convening this workshop to facilitate the use of integrated modeling to inform and improve local, regional and national policy decisions relevant to climate change adaptation and mitigation strategies. The workshop in which you are about to participate is intended to do several things:

- Bring together empirical scientists, modelers, economists, social scientists, and public policy experts to help ensure that model development aligns with climate change policy design, management and decision-making needs.
- Connect the climate change data producers with the climate change data users. Make existing resources accessible to stakeholders in the field.
- Highlight successful case studies of intra-agency, inter-agency, academia, public, and private sector systems analysis and integrated modeling for climate change impacts.

We have developed the workshop agenda to include a mix of keynote presentations, case-study and technical presentations. We will also be having two break-out sessions in order to have small group discussions about your specific modeling and modeling output needs. Discussions will identify the

challenges and opportunities represented by specific decision making needs and will chart a path forward for the development and use of integrated modeling to respond to those needs. This workshop seeks to build on the great synthesis work published in recent climate change white papers. Findings and recommendations from some of those white papers, including the United States Global Change Research Program, the National Research Council, and the White House Council on Environmental Quality, have been summarized in the back of this participants guide.

A natural component of face to face meetings is the opportunity to connect experts from different disciplines and to develop working relationships and collaboration opportunities. With that in mind we will help facilitate collaboration by posting collaborative project sign-up sheets in the break area. The sign-up sheets will include space for a title and description of the project, the initiation team, the time line, resources, goal, and outcome of the project. If a presentation, break-out session, or conversation during a break sparks a collaboration idea, fill out a collaborative project sheet to give other workshop participants an opportunity to join. We will reserve some time during the second break-out session plenary reports to present collaboration project ideas to your fellow participants.

We invite you to look ahead in this Participants Guide which includes a workshop agenda, collaboration project sign-up template, background information and detailed information about the break-out sessions. Please take the time to examine the Participants Guide and the break-out session questions in preparation for the discussions.

Once again, we thank you for your enthusiasm and willingness to engage with us in addressing these difficult but critical issues. We are looking forward to your active involvement to make this workshop a resounding success.

Sincerely,
The Workshop Planning Committee

"Climate change must be considered and integrated into all aspects of our work."

"In all aspects of our work, from problem identification, to research design and conduct, to implementation of solutions, we must involve the widest diversity of disciplines."

"If EPA is to solve these challenging problems, we must rely on integrated, trans-disciplinary research that complements traditional single-discipline approaches."

--- EPA Draft FY 2011-2015 Strategic Plan

Workshop Planning Committee

- Catherine Allen, EPA Office of Policy, Economics and Innovation
- Amanda Babson, EPA Office of Research and Development
- Jennifer Brady, EPA Office of Solid Waste and Emergency Response
- Ed Coe, EPA, Office of Air and Radiation
- Pat Dolwick, EPA, Office of Air and Radiation
- Rich Dumas, EPA, Office of Chemical Safety and Pollution Prevention
- Rick Durbrow, EPA Region 4
- Robert Elleman, EPA Region 10
- Tom Fontaine, EPA Office of Research and Development
- Noha Gaber, EPA Office of the Science Advisor
- Tim Gleason, EPA Region 1
- Michael Hiscock, EPA Office of the Science Advisor
- Serpil Kayin, EPA, Office of Air and Radiation
- Patrick Kelly, EPA Region 6
- Robyn Kenney, EPA, Office of Air and Radiation
- David Kryak, EPA Office of Research and Development
- Lew Linker, EPA Region 3, Chesapeake Bay Program Office
- Edward Linky, EPA Region 2
- Dan Loughlin, EPA Office of Research and Development
- George Luber, CDC Climate Change Program
- Jeremy Martinich, EPA Office of Air and Radiation
- Ken Mitchell, EPA Region 4
- Mahri Monson, EPA, Office of Enforcement and Compliance
- Chris Moore, EPA, National Center for Environmental Economics
- Philip Morefield, EPA Office of Research and Development
- Michael Morton, EPA Region 6
- Gabriel Olchin, EPA Office of the Science Advisor
- Rob Pinder, EPA Office of Research and Development
- John Powers, EPA Office of Water
- Sarah Rizk, EPA Region 9
- Shubhayu Saha, CDC Climate Change Program
- Winona Victery, EPA Region 9
- Stephanie Waldhoff, EPA, Office of Air and Radiation

Workshop Agenda

Day 1: February 1, 2011

7:00–8:00	**Workshop Registration**
8:00–8:15	**WORKSHOP INTRODUCTION / WELCOME** Michael Hiscock, EPA Office of the Science Advisor
8:15-10:00	**TAKING ACTION ON CLIMATE CHANGE FROM A SENIOR DECISION MAKING PERSPECTIVE** Keynote Speakers: ***Regional Perspective: "Regional Perspective on Climate Change Adaptation: Issues and Decision Support Needs"*** Beverly Banister, EPA Region 4 Air, Pesticides and Toxics Management Division Director ***Federal Perspective: "Challenges for Integrated Modeling"*** Andy Miller, EPA National Program Director for Global Change Research ***Local Perspective*** Mandy Mahoney, Atlanta Mayor's Office, Director of Sustainability ***"The Importance of Mainstreaming Climate Adaptation into EPA's Programs and Rules"*** Joel Scheraga, EPA Senior Advisor for Climate Adaptation
10:00–10:20	**Break**
10:20–12:30	**INTEGRATED MODELING TO ASSESS CLIMATE CHANGE IMPACTS ON THE ENVIRONMENT AND HUMAN HEALTH** Session Moderator: Ken Mitchell, EPA Region 4 ***I. National Case Study: EPA Cross-Agency Integrated Modeling Effort to Support Air Quality Assessment*** ***"Overview of Integrated Modeling Effort to Support Air Quality Assessment"*** Bryan Bloomer, EPA National Center for Environmental Research ***"Integrated Climate and Land Use Scenarios (ICLUS) and the Environmental Benefits Mapping and Analysis Program (BENMAP)"*** Philip Morefield, EPA National Center for Environmental Assessment ***II. Regional / Local Case Study: Outcomes of the Dec 2010 Austin Systems Thinking Workshop on Local Climate Change Effects on Human Health and Well Being*** ***"Systems Thinking Process"*** Tom Fontaine, Western Ecology Division, EPA Office of Research and Development ***"Systems Thinking Products"*** Roel Boumans, GUND Institute for Ecological Economics, University of Vermont

	"Integrated Assessment Modeling to Support Local Public Health Adaptation to Climate Change" George Luber, CDC, Associate Director of the Global Climate Change Program ***"Systems Thinking Process to Support Decision Making in Austin"*** Marc Coudert, Environmental Program Coordinator, Austin, Texas Climate Protection Program ***Panel Discussion to follow presentations***	
12:30–1:30	**Lunch (on your own)**	
1:30–3:00	**INTEGRATED MODELING TO ASSESS CLIMATE CHANGE IMPACTS ON THE ENVIRONMENT AND HUMAN HEALTH** Session Moderator: John Powers, EPA Office of Water ***Local Case Study: "Oyster River Culvert Analysis using Climate Change Scenarios"*** Michael Simpson, Antioch University ***Regional Case Study: "Key Issues for Using Integrated Modeling in Multi-scale Climate Change Vulnerability Assessments, with Watershed and Estuary examples"*** Amanda Babson, EPA Global Change Research Program ***National Case Study: "Hydrologic and Water Quality System, A National Watershed and Water Quality Assessment Tool"*** Raghavan Srinivasan, Texas A&M University ***Panel Discussion to follow presentations***	
3:00–3:40	**INTRODUCTION AND CHARGE FOR DAY 1 BREAK-OUT SESSION:** ***"Modeling For Action: Creating Integrated Models that Get Used"*** Drew Jones, Climate Interactive	
3:40–4:00	**Break**	
4:00–5:30	**BREAK-OUT SESSION: DECISION MAKING NEEDS AND THE ROLE OF INTEGRATED MODELING**	
	Red Group Facilitators: Drew Jones / Mahri Monson Rapporteur: Bob Howard Room: Peachtree A	**Green Group** Facilitators: Winona Victery / Noha Gaber Rapporteur: Rick Gillam Room: Peachtree B
	Yellow Group Facilitators: Linda Rimer / Jim Fox Rapporteur: Kedesch Altidor Room: Peachtree C	**Blue Group** Facilitators: Bob Horn / Gabriel Olchin Rapporteur: Daniel Garver Room: The Lenox Room
5:30–7:00	**Poster Session**	

Day 2: February 2, 2011

<table>
<tr><td>8:30–9:45</td><td colspan="2">Day 1 Break-Out Session Reporting and Discussion
Session Moderator: Gabriel Olchin, EPA Office of the Science Advisor</td></tr>
<tr><td>9:45–12:00</td><td colspan="2">INTEGRATED MODELING FOR TAKING ACTION ON CLIMATE CHANGE
Session Moderator: Cynthia Bohn, U.S. Fish and Wildlife Service

“CRAFT Model Regional Partnership”
Jim Fox, UNC Asheville, National Environmental Modeling and Analysis Center

“Climate Resilience Evaluation and Awareness Tool”
Steve Fries, Computer Sciences Corporation for Curt Baranowski, EPA Office of Water

“Modeling scenarios of the future using the EPA 9-Region MARKAL: Energy, climate and emissions”
Dan Loughlin, EPA, National Risk Management Research Laboratory

--------- BREAK [10:30-10:50] ----------

“Water Supply Stress Modeling and Technology Transfer Mechanisms: Discovering and Applying Climate Change Science”
Steve McNulty, Southern Research Station, USDA Forest Service
and
David Meriwether, Southern Region Planning, USDA Forest Service

“Tools and Resources for Estimating the Multiple Benefits of Clean Energy”
Robyn Kenney, EPA Office of Air and Radiation

Panel Discussion to follow presentations</td></tr>
<tr><td>12:00–12:40</td><td colspan="2">INTRODUCTION AND CHARGE FOR DAY 2 BREAK-OUT SESSION:

“Information Murals, Context and Detail for Decision-Makers”
Robert Horn, Stanford University</td></tr>
<tr><td>12:40–1:40</td><td colspan="2">Lunch (on your own)</td></tr>
<tr><td rowspan="3">1:40–3:10</td><td colspan="2">BREAK-OUT SESSION: IDENTIFYING THE CURRENT MODELING CAPABILITIES, GAPS, AND NEEDS TO BRIDGE THOSE GAPS</td></tr>
<tr><td>Red Group
Facilitators: Drew Jones / Mahri Monson
Rapporteur: Bob Howard
Room: Peachtree A</td><td>Green Group
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Rapporteur: Daniel Garver
Room: The Lenox Room</td></tr>
<tr><td>3:10–3:30</td><td colspan="2">Break</td></tr>
<tr><td>3:30–4:30</td><td colspan="2">Day 2 Break-Out Session Reporting and Discussion
Session Moderator: Noha Gaber, EPA Office of the Science Advisor</td></tr>
<tr><td>4:30–5:00</td><td colspan="2">Wrap-Up Discussion
Session Moderator: Noha Gaber, EPA Office of the Science Advisor</td></tr>
<tr><td>5:00</td><td colspan="2">Adjourn</td></tr>
</table>

Collaborative Project Sign-up

A natural component of face to face meetings is the opportunity to connect experts from different disciplines and to develop working relationships and collaboration opportunities. With that in mind we will help facilitate collaboration by posting collaborative project sign-up sheets in the break area. If a presentation, break-out session or conversation during a break sparks a collaboration idea, fill out a collaborative project sheet to give other workshop participants an opportunity to join. We will reserve some time during the second break-out session plenary reports to present some collaboration project ideas to your fellow participants.

Project Title:
Project Description:
Project Coordinator:
Timeline:
Resources:
Product/Outcome:
Sign up: (Name and e-mail address)

Basic Discussion Group Principles

- **Stay on topic:** Start from the “big picture” before moving into details. Jumping to details prematurely can consume a lot of time on a topic that the group may later decide is unnecessary. A “Parking Lot” of ideas will be available to post ideas/comments to ensure that they are addressed at the appropriate time.

- **Everyone shares the responsibility for making the meeting a success:** This meeting is a true collaboration between all attendees, including the facilitators. If you have a suggestion that will enable the participants to be more effective, please suggest it either orally or through a posted note.

- **Listen and understand:** All participants bring to this meeting a diversity of experiences, ideas, knowledge, and perspectives. Seek to understand other’s comments before advocating your own.

- **Be transparent:** Our assumption is that all participants are coming to this meeting with the intent of working collaboratively with other participants to achieve the workshop goals.

- **First brainstorm, then critique:** The most creative ideas emerge through an uninterrupted accumulation of participant comments built upon the suggestions of others in the group. Often the seemingly wildest ideas stretch thinking to tangible innovations. Avoid premature critiquing that can unintentionally shut down the creative process.

- **Provide everyone an equal opportunity to speak:** Part of our diversity includes variations in how we prefer to express ourselves. Freely offer your perspectives and allow others the space to express theirs. Self-managing our air time benefits the discussion by allowing a variety of perspectives and insights to be heard including some that have not occurred to others.

- **Commit to being fully present:** Please turn off all cell phones; put away the laptop computers/Palm Pilots/Blackberrys. You can always check them during breaks.

Introduction to the Break-Out Sessions

Several high-level documents have been published recently about the scientific needs and the adaptation strategies for understanding and taking action on climate change impacts. Findings and recommendations from the United States Global Change Research Program, the National Research Council, and the White House Council on Environmental Quality have been summarized in the back of this participants guide.

These papers unanimously report that climate change impacts are already occurring and will have increased consequences in the future. The documents identify current and potential impacts by sector (i.e. water, energy supply, transportation, ecosystems) and region (i.e. Midwest, Coasts). There is awareness that most of the challenges will be faced and that most of the decisions will be made at the local level, but that federal agencies and national organizations have a role in showing leadership and providing decision support. Integrated modeling is recognized as an important component to supporting decision making on a national, regional, and local scale.

Our goal in these break-out sessions is to inform and improve integrated modeling to support decision making for climate change impacts. We will have break-out sessions both days of this workshop. The output of these break-out sessions will inform recommendations on the future needs of integrated modeling for the assessment and response to climate change impacts.

- On the first day, our small groups will discuss decision making needs that could be informed by integrated modeling (i.e. what policy drivers concern you or what decisions are you making). Each break-out group will then report out on their discussion on the morning of the second day.

- With the background of the break-out reports, plenary presentations, and panel discussions, the break-out groups will reconvene on Day 2 to identify current modeling capabilities, gaps, and needs to bridge those gaps.

Break-Out Session 1

DECISION MAKING NEEDS AND THE ROLE OF INTEGRATED MODELING

February 1st 4:00-5:30pm

PURPOSE:
The purpose of this break-out session is to identify the information needs related to climate change impacts to support decision making on a national, regional and local scale.

OUTPUT AND REPORT OUT:
- Synthesis of general decision-support needs for the group.
- Modeling and data needs for a specific national, regional or local-scale decision-support example.

BREAK-OUT GROUPS:

Red Group Facilitated by: Drew Jones / Mahri Monson Rapporteur: Bob Howard Room: Peachtree A	**Yellow Group** Facilitated by: Linda Rimer / Jim Fox Rapporteur: Kedesch Altidor Room: Peachtree C
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Backup Facilitator: Katherine Sciera

CHARGE QUESTIONS:

PART 1 (45 minutes)
What decision making needs related to climate change impacts are you interested in?
a. What is the scope of the decision making need (i.e. planning, guidance, policy, regulation)?
b. What are the climate change impacts related to the decision making need?
c. What is the spatial scale of the decision making need (national, regional, local)?
d. What is the temporal scale of the decision making need?

PART 2 (45 minutes)
Given the decision making needs identified in Part 1, select and define a specific decision making need that can be analyzed using a systems thinking or integrated modeling approach. This specific decision making need will also be considered in the Day 2 break-out session.

a. What information is required from the data or models (model output) to inform the specific decision?
b. At what stages in the decision making process is this information needed?
c. What are the tolerances for uncertainty to inform this decision?

Example of a systems thinking analysis across sectors for changes in precipitation.

Integrated Themes of Water-Related Impacts by Sector	
Sector	**Examples of Water-Related Impacts**
Human Health	Heavy downpours increase incidence of waterborne disease and floods, resulting in potential hazards to human life and health.
Energy Supply and Use	Hydropower production is reduced due to low flows in some regions. Power generation is reduced in fossil fuel and nuclear plants due to increased water temperatures and reduced cooling water availability.
Transportation	Floods and droughts disrupt transportation. Heavy downpours affect harbor infrastructure and inland waterways. Declining Great Lakes levels reduce freight capacity.
Agriculture and Forests	Intense precipitation can delay spring planting and damage crops. Earlier spring snowmelt leads to increased number of forest fires.
Ecosystems	Coldwater fish threatened by rising water temperatures (due to decreased watershed precipitation).

Break-Out Session 2

IDENTIFYING THE CURRENT MODELING CAPABILITIES, GAPS AND NEEDS TO BRIDGE THOSE GAPS

February 2nd 1:40-3:10pm

PURPOSE:
In this break-out session we will revisit the specific decision making need selected on Day 1. We will determine our current modeling capabilities to address the decision support needs, identify the gaps in our current capabilities, and describe what needs to be developed in order to bridge these gaps. During the Day 1 break-out sessions, we discussed what we need. In this break-out session, we will discuss how to get there.

OUTPUT AND REPORT OUT:
- A discussion of the current modeling capabilities, gaps, and needs to bridge those gaps.

GROUPS:

Red Group Facilitated by: Drew Jones / Mahri Monson Rapporteur: Bob Howard Room: Peachtree A	**Yellow Group** Facilitated by: Linda Rimer / Jim Fox Rapporteur: Kedesch Altidor Room: Peachtree C
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CHARGE QUESTIONS:

For the decision support need defined in the first break-out session:

1. What are our current capabilities to address the modeling and decision support needs?
    a. What models are available?
    b. What data is available? What is the temporal and spatial scale of the data?
    c. What inputs do the models require (consider temporal and spatial scales)?

2. What are the gaps for supporting our decision making needs?

3. What needs to be developed to bridge these gaps?

Poster Session Abstracts

POSTERS

01 Using *Envision* for climate adaptation and other CDSC activities

Author: Kathie Dello
Affiliation: Oregon Climate Change Research Institute/Climate Decision Support Consortium

Envision is a GIS-based tool for scenario based community and regional planning and environmental assessments and will be used by the Climate Decision Support Consortium. The CDSC will work with decision-makers to explore future scenarios, using an "explore-then-test" approach. This tool will be used by the CDSC in helping stakeholders explore adaptation options. We will also describe current and planned activities of the Climate Decision Support Consortium, the new Pacific Northwest RISA, housed at Oregon State University.

02 Modeling Water Availability and Allocation Under Climate Change

Author: Robert Dykes
Affiliation: Research Triangle Institute

The model utilizes NHDPlus to provide a unified hydrologic network and deliver inputs to a modified version of the widely used Generalized Water Loading Function (GWLF) hydrologic model. Databases on temperature and precipitation measures, existing water withdrawals and returns, land use and land cover, and other relevant model parameters have been indexed onto each NHDPlus catchment enabling the model to run for any user-defined geography ranging from a single NHDPlus catchment to a 4-digit Hydrologic Unit at any location within the contiguous U.S. This architecture provides a high degree of scalability and portability.

03 Building the Delivery Truck – Developing Tools that Allow Decision Makers to Move from Assessment to Action

Author: Jim Fox, Karin Lichtenstein, Todd Pierce, J. Greg Dobson, Mark Phillips, Jeff Hicks, Matt Hutchins and Bridget O'Hara
Affiliation: UNC Asheville National Environmental Modeling and Analysis Center

Decision makers are being asked to cope with the reality of climate change. This new challenge contains a complexity of issues including accessing information, understanding uncertainty, and considering vulnerabilities. As our society begins to think about impacts from climate change, it is critical that decision and policy makers have a firm understanding of these issues in order to assess risk and develop adaptation strategies at local levels. Simply providing decision makers with global climate information, models, and products does not equate to successful use and understanding of the information that allows for action. The University of North Carolina at Asheville's National Environmental Modeling and Analysis Center (NEMAC), with support from NOAA's National Climatic Data Center and the USDA Forest Service Eastern Forest Environmental Threat Assessment Center, has developed a portfolio of tools for decision support and civic engagement. The process of creating these tools requires combining climate information with stakeholder values and data to guide the application of climate information from "global to regional to local levels," and for communicating with decision makers. The goal of these tools is to support the assessment of vulnerabilities and assist communities in building greater resiliency. The portfolio of tools covers multiple regions across the United States with particular emphasis on the Southeast. NEMAC's approach has supported decisions by gaining a better understanding of risk and vulnerabilities to climate impacts, and incorporating end-user needs throughout the process. Issues regarding scale and data formats are also addressed, especially as climate information is applied at local levels. Local decision makers are engaged directly through workshops to facilitate proper communication and to guarantee that this user group understands how to integrate climate information with other drivers in their communities. While

climate is an important factor for decision makers, their decisions are not solely climate driven, thus the foundation of this approach lies in assessing how climate integrates with other factors that they manage and identifying the most efficient way for users to engage with the information. By providing tools that allow the users to examine alternatives in the light of uncertainty, better action can be taken to address the most critical issues.

04 A New Modeling Approach to Forecast Building Energy Demands during Extreme Heat Events in Complex Cities

Author: Jorge Gonzalez
Affiliation: The City College of NY

The thermal response of a large city including the energy production aspects of it are explored for a large and complex city using urbanized atmospheric mesoscale modeling. The Weather Research and Forecasting (WRF) mesocale model is coupled to a multi-layer urban canopy model that considers thermal and mechanical effects of the urban environment including a building scale energy model to account for anthropogenic heat contributions due to indoor-outdoor temperature differences. This new urban parameterization is used to evaluate the evolution and the resulting urban heat island formation associated to a 3-day heat wave in New York City (NYC) during the summer of 2010. High resolution (250 m.) urban canopy parameters (UCPs) from the National Urban Database were employed to initialize the multi-layer urban parameterization. The precision of the numerical simulations is evaluated using a range of observations. Data from a dense network of surface weather stations, wind profilers and Lidar measurements are compared to model outputs over Manhattan and its surroundings during the 3-days event. The thermal and drag effects of buildings represented in the multilayer urban canopy model improves simulations over urban regions giving better estimates of the surface temperature and wind speed. An accurate representation of the nocturnal urban heat island registered over NYC in the event was obtained from the improved model. The accuracy of the simulation is further assessed against more simplified urban parameterizations models with positive results with new approach. Results are further used to quantify the energy consumption of the buildings during the heat wave, and to explore alternatives to mitigate the intensity of the UHI during the extreme event.

05 Southeast Climate Consortium

Author: Keith Ingram
Affiliation: Southeast Climate Consortium & University of Florida

Growing from the Florida Consortium, which was founded in 1996, the Southeast Climate Consortium (SECC) mission is to use advances in climate sciences, including improved capabilities to forecast seasonal climate and long-term climate change, to provide scientifically sound information and decision support tools for agricultural ecosystems, forests and other terrestrial ecosystems, and coastal ecosystems of the SE USA. As a multidisciplinary, multi-institutional team, the SECC conducts research and outreach to a broad community of users and forms partnerships with extension and education organizations to ensure that SECC products are relevant, reliable, and delivered to the public by these organizations through their networks and mechanisms. Until about 4 years ago, SECC research and extension focused primarily on the effects of seasonal climate variability in the agriculture sector, which is highly vulnerable to climate risks. With increasing awareness of climate change and its potential impacts, demand has grown for information on climate change and for information targeted to other ecosystems. The SECC is adopting a new organization to address the climate information needs of coastal and terrestrial ecosystems in addition to the agricultural ecosystems. Using RISA and leveraged funding, we will work in partnership with appropriate boundary organizations to assess end user needs and to develop and improve climate information for each of these ecosystems that can be used to manage risks and to pursue new economic opportunities. Research for the coastal and terrestrial ecosystems will build on the success of the SECC in providing an effective decision support system for agriculture, AgroClimate.org. Research and extension activities will

emphasize collaboration among investigators from natural resources sciences, including climate, water resources, land, and energy, and investigators from applications sciences, including extension and outreach, human dimensions, integrated participatory systems analysis. Our four scientific objectives are: 1) Working with boundary organizations, planners, regional data clearinghouses, and other stakeholders, assess the needs of decision makers for climate information, their access to and applications of climate information, and time-scales for needed information; 2) Based on stakeholder assessments, develop partnerships with appropriate boundary organizations to meet the climate information needs of stakeholders, particularly in coastal and other terrestrial ecosystems; 3) Provide reliable, timely, probabilistic, and local climate information according to stakeholder needs for adaptation and resilience to climate change and climate variability. Providing this information will require production of downscaled forecasts at the local level and at 1- to 30-year time scales, as well as maintaining and providing historical data and analyses for the region; 4) Through integrated, multi-disciplinary activities, develop decision support tools and information delivery systems that give decision makers access to climate information that will help decision makers manage risks associated with climate change at various time scales.

06 Template for Assessing Climate Change Impacts and Management Options

Author: [1]Steve McNulty, [1]Emrys Treasure, [1]Jennifer Moore Myers, [1]Robert Herring, [2]Chris Liggett, [2]David Meriwether, [2]Paul Arndt
Affiliation: [1]Eastern Forest Environmental Threat Assessment Center, Southern Research Station, USDA Forest Service; [2]Southern Region, USDA Forest Service

The *Template for Assessing Climate Change Impacts and Management Options* (TACCIMO) is a web-based tool adopted by the Southern Region of the US Forest Service to assist land managers and planners with standardized evaluation of climate change implications for sustainable forest management. TACCIMO is an information framework that provides access to climate change science as apparent in the body of peer reviewed literature with emphasis on forest ecosystem management. A custom mapping application provides national extent downscaled climate data and other spatially explicit models relevant to evaluating climate impacts on forests (e.g. Water Supply Stress Index). Report generators in both applications assist users in considering the range of likely future climate conditions and impacts/ management options at multiple scales. For US Forest Service users, science based content can be automatically linked with management conditions and capabilities as apparent in National Forest land and resource management plans. The TACCIMO concept and products will be described as an example of applied integrated modeling and technology transfer.

07 Characterizing extreme events for adaptation

Author: Kevin Moody
Affiliation: US Department of Transportation, Federal Highway Administration

From heat waves to flooding, changes in the magnitude and frequency are increasingly apparent to infrastructure managers. The state of climate change models limits forecast precisions, so investment decisions are increasingly likely to be made using scenarios than probabilistic analyses. Reviews of trends data, however, show that understanding the underlying causal relationships between extreme events and harm to life and property allows for much more informed vulnerability analysis and adaptation recommendations. Three examples are discussed: riverine flooding; coastal flooding, and heat waves.

08 **Assessment of Precipitation Projections and Derived Estimates of Evapotranspiration from NARCCAP models for Water Resources Applications in Florida**

Author: Jayantha Obeysekera
Affiliation: Hydrologic and Environmental Systems Modeling Department, South Florida Water Management District

Precipitation and Evapotranspiration are the two most important predictors of the amount of water available for planning investigations of future projects to meets the needs of the urban, agricultural, and natural systems of Florida. Although General Circulation Models (GCMs) provide long-range projections for the future, their course scales, in the inability to represent Florida peninsula well, the projections from these models are not sufficiently reliable for planning and operation of large-scale projects in Florida. Although, higher-resolution, statistically downscaled precipitation and temperature projections are available, there is no guarantee that such information can adequately represent complex spatial patterns associated with mesoscale phenomena of the region, and the potential linkages to such teleconnections as ENSO and AMO. We investigate the potential of using Regional Climate (RCMs) models made available from the NARCCAP program as an alternative to project future precipitation regimes as well as the derived estimates of evapotranspiration from the primary meteorological information provided by the higher resolution models. We investigate ability of NARCCAP models to simulate the spatial and seasonal patterns of both precipitation and temperature. Using the Penman-Monteith model for computing evapotranspiration, and the maximum and minimum temperature, incoming solar radiation, wind, and humidity variables of NARCCAP models, we investigate the magnitude of the derived estimates of evapotranspiration and compare them with records available for several locations in Florida.

09 **Historical Trends in Florida Temperature and Precipitation**

Author: Michelle M. Irizarry-Ortiz and Jayantha Obeysekera
Affiliation: Hydrologic and Environmental Systems Modeling Department, South Florida Water Management District

Florida is characterized by its low topographic relief, unique hydrology, and the large inter-annual variability of precipitation. These features coupled with a large and growing population along the low-lying coastal zone make the state especially vulnerable to climate change. In this poster, we present a comprehensive collection of climate metrics applied to study historical trends in both averages and extremes of precipitation and temperature in the state. The data analyzed consists of long-term records (1892-2008) of precipitation and raw (unadjusted) temperature at 32 stations distributed throughout the state. To evaluate trends in climate metrics, we use Zhang's iterative pre-whitening method, which is based on non-parametric regression and aims to separate positive autocorrelation from trend present in time series. Results of the trend analysis show a general decrease in wet season precipitation. This reduction in wet season precipitation is most evident for the month of May and is possibly tied to a delayed onset of the wet season in Florida. In contrast, there seems to be an increase in the number of wet days during the dry season, especially during the NDJ months. We found that the number of dog days (above > 26.7 ºC/80 ºF) during the year and specifically during the wet season has increased at many stations. Consistent with global observations, the data shows a widespread decrease in the daily temperature range (DTR) for the post-1950 period mainly due to increased daily minimum temperature (Tmin). Although we did not attempt to formally attribute these trends to natural versus anthropogenic causes, we find that the urban heat island effect is at least partially responsible for the increase in Tmin and its corresponding decrease in DTR at urbanized stations compared to nearby rural stations. We recommend that a formal trend attribution study be conducted for the region in the future.

10 Dynamical Downscaling of NASA/GISS ModelE: Continuous, Multi-year WRF Simulations

Author: Tanya Otte
Affiliation: U.S. Environmental Protection Agency

The WRF Model is being used at the U.S. EPA for dynamical downscaling of the NASA/GISS ModelE fields to assess regional impacts of climate change in the United States. The ModelE fields were included in the IPCC Fourth Assessment Report, and updated science in the improved ModelE will contribute toward the IPCC Fifth Assessment Report. The dynamically downscaled climate fields from WRF ultimately will be used to predict the regional impacts of climate change on air quality and other regional environmental concerns. The WRF model has been successfully linked to the ModelE fields in their raw hybrid vertical coordinate, and continuous, multi-year WRF downscaling simulations have been performed. The use of nudging for downscaled regional climate simulations has been somewhat controversial over the past several years but has been recently attracting attention. Several recent studies that have used reanalysis (i.e., verifiable) fields as a proxy for GCM input have shown that nudging can be beneficial toward achieving the desired downscaled fields. In this study, the value of nudging will be shown using fields from ModelE that are downscaled using WRF. Several different methods of nudging are explored, and it will be shown that the method of nudging and the choices made with respect to how nudging is used in WRF are extremely critical to balance the constraint of ModelE against the freedom of WRF to develop its own fields.

11 Decision-support tools for understanding the impacts of short-lived climate forcers

Author: Robert Pinder
Affiliation: U.S. Environmental Protection Agency

Because climate change occurs over decades, scenarios are used to understand the impacts of policy decisions on a range of future outcomes. However, fully assessing the air quality and climate change impacts of a given emission scenario requires extensive computational modeling and analysis. Tools that can rapidly inform decision-makers and stakeholders are a first-order need. To meet this need, we are developing GLIMPSE -- a framework for connecting atmospheric chemistry, radiative forcing, and energy-economy models to rapidly understand the integrated air quality and climate change impacts of US emission scenarios. GLIMPSE stands for Geos-CHEM LIDORT Integrated with MARKAL for the Purpose of Scenario Exploration. More information is available at http://www.epa.gov/AMD/Climate/GLIMPSE.html

12 Integrated watershed modeling forecosystem services: the Albemarle-Pamlico Watershed and Estuary Study (APWES)

Author: Brenda Rashleigh, Darryl Keith, Donna Schwede, Stephen Kraemer
Affiliation: U.S. Environmental Protection Agency

The Albemarle-Pamlico Watershed and Estuary Study (APWES) is a place-based study for the U.S. EPA Ecosystem Services Research Program conducted through collaboration across the EPA Office of Research and Development. The APWES is developing ecosystem services science to inform management decisions, including climate adaptation, in the Albemarle-Pamlico watershed and estuary in North Carolina and Virginia. Seven ecosystem services will be considered for the region: clean air; clean water; climate resilience; flood and storm protection; food, fiber, and fuel; recreation; and biodiversity. This study uses a systems approach to address the drivers, pressures, state, ecosystem services, and management response; modeling will be used to relate changes in drivers and pressures to changes in ecosystem services. This research will include empirical and mechanistic modeling for the air (CMAQ), watershed (SWAT, WASP), groundwater (GFLOW, MODFLOW), coastal wetlands (SLAMM), estuary (FVCOM, ENM), and freshwater and estuarine species (SMURF, Population models). Models will be informed by mapping and monitoring and linked within modeling frameworks. Decision support tools, including an interactive web-based software application and Bayesian networks, are being developed to understand how management decision alternatives – developed with stakeholder input – alter services, so that quantified services can be used to inform decisions. The APWES will examine tradeoffs or synergies among services under alternative management decisions, and seeks to understand how ecosystems can be managed sustainably for ecosystem protection and economic benefit.

13 Assessing the Climate Change Impact on Rainfall Intensity-Duration-Frequency (IDF) Curves in the Apalachicola River Basin, Florida

Author: Dingbao Wang
Affiliation: University of Central Florida

To model the climate change impact on the hydrology of the coastal area, both sea level rise and the inland precipitation and temperature change need to be considered. The change of rainfall characteristics especially for extreme events, which are represented by rainfall intensity-duration-frequency (IDF) curves, is important for the water flow and sediment transport to and within coastal ecosystems. Predicted future climate change impacts for Florida include higher temperatures and increases in precipitation, leading to an intensification of the hydrologic cycle. There are several challenges to predict the IDF curves under future climate change scenarios: 1) GCMs (general circulation models) or RCMs (regional climate models) perform well for general statistics (such as annual or monthly rainfall) but not for extreme rainfall events at the local scale; 2) the temporal disaggregation of rainfall from GCM or RCM may be needed, e.g., from daily to hourly. Taking the Apalachicola River Basin in Florida as an example, this study assesses the change of IDF curves from baseline (e.g., current condition) to the future (e.g., 2070-2100) by two methods. One method is to construct a statistical IDF model based on the long-term rainfall records where the change of IDF curves is investigated from a retrospective view. The statistical model is applied to predict the IDF curves in the future. The other method is to assess the IDF curve changes using an ensemble of RCMs. The results from each approach will be compared and contrasted, and shown to be beneficial for simulating hydrodynamics and sediment transport over inland areas when assessing impacts of climate change.

14 Assessing the Nation's Ecosystems for Carbon Sequestration Capacity

Author: Zhiliang Zhu, Anne Wein
Affiliation: United States Geologic Survey

Understanding capacities of ecosystems to sequester carbon and opportunities to reduce greenhouse gas emissions provides science information to support formulation of policies governing climate change mitigation, adaptation, and land-management strategies. The 2007 Energy Independence and Security Act (EISA) requires developing a methodology and conducting an assessment that estimates potential capacities of the Nation's ecosystems to increase carbon sequestration by considering effects of major controlling processes including mitigation strategies in support of a range of policy applications. The national assessment covers all ecosystems including major terrestrial (forest, cropland, wetland, shrub and grassland) and aquatic (river, lake, estuary, and coastal waters) systems. It covers all lands of the Nation including Alaska. The assessment estimates ecosystem capacities for carbon sequestration based on analysis of major controlling processes such as climate change, land use and land cover change, land management activities, and ecosystem disturbances. The ecosystem capacity estimates are assessed for both a baseline (2001-2010) and future projections (2011-2050, using IPCC SRES scenarios coupled with regionally constructed mitigation scenarios). The assessment will be conducted during the next 3-4 years using the methodology developed (available at www.usgs.gov/global_change/carbon). In this poster presentation, we will introduce requirements and scope of the assessment, introduce current knowledge about ecosystem carbon sequestration, and discuss our technical plan to conduct the assessment.

15 Vulnerability Analysis of Transportation Network under Scenarios of Sea-level rise

Author: Zhong-Ren Peng
Affiliation: University of Florida

Sea-level rise increasingly becomes a major concern for transportation planners, engineers and decision makers, especially for coastal regions. It is very important to quantify the vulnerability of transportation networks and develop adaptation strategies. This paper develops an accessibility-based transportation network vulnerability analysis process to quantify network-wide transportation vulnerability and identify the most vulnerable areas under different sea-level rise scenarios. The accessibility reduction rate before and after inundation is calculated to measure the potential consequences. The probability of different sea-level rise scenarios together with the overall accessibility reduction contributes to the overall transportation network vulnerability. Most notably, the traffic analysis zones with the most accessibility reduction are considered the most vulnerable areas. This methodology is applied to south Miami transportation network under two different sea-level rise scenarios for the year 2060. We estimated the extent of road network vulnerability and accessibility reduction of individual traffic analysis zones. The results show that there is almost 100 percent accessibility reduction for traffic analysis zones with all roads inundated and as high as 30 percent accessibility reduction in zones with some or no road directly affected. This information can help local transportation planners, engineers and decision makers identify the most vulnerable areas and transportation facilities as a result of sea-level rise, in order to make better and more informed decisions about adaptation planning and retrofitting.

16 Modeling land use change projections for regional water planning in the wake of climate change

Author: Liz Kramer
Affiliation: University of Georgia

Land use change projections for 2010, 2020, 2030, 2040, and 2050, were developed using SLUETH for the Georgia EPD as part of the regional water planning process. Population projections were used to bound potential urban growth as well as projections of agricultural water demands for irrigation. The output of these models were linked with water quality and quantity models to develop a better understanding of how changes in future land use will impact water availability and quality. The output allows water planners to assess how availability will interact with demand. Changes in precipitation can be linked to these outputs to assess future water availability and infrastructure needs.

17 Climate Scenarios and Decision Support Resources for Alaska

Author: Sarah Trainor
Affiliation: University of Alaska, Fairbanks

Alaska and the Arctic are warming more rapidly than any other place on the planet. Impacts are already experienced in Alaska's economy, infrastructure, transportation, and traditional food systems. Demand for climate change information and assistance in adaptation planning is increasing state-wide. Stakeholders throughout the state such as Alaska's state government, tribal governments, communities, industry, as well as the state and federal agencies that manage transportation and natural resources are seeking assistance as they plan for and adapt to climate change. Information needs are wide-spread and varied. The Alaska Center for Climate Assessment and Policy (ACCAP) and the Scenarios Network for Alaska and Arctic Planning (SNAP), at the University of Alaska, Fairbanks, work closely together and with regional stakeholders to provide a suite of climate information and decision-support tools and services. Using output from the IPCC models that perform best at northern latitudes and PRISM climatology, SNAP provides downscaled projections of possible future temperature, precipitation and growing season length. One of SNAPs recent projects involves collaboration with Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, U.S. Geological Survey, the Alaska Department of Fish and Game, and multiple non-profit organizations resulting in scenario projections of shifting ecosystems that will aid in land, resource and wildlife management. Some of the decision support tools available from ACCAP and SNAP include projected temperature and precipitation charts for every community in Alaska, a quarterly climate review newsletter, a sea ice information tutorial and resource manual, a decision-support guidebook for communities at risk to relocation, and a monthly webinar series and digital archive focused on Alaska-specific climate related topics.

Speaker Biographies

Amanda Babson
Amanda Babson is a physical scientist with EPA's Global Change Research Program, where she is working on climate change vulnerability assessments and adaptation planning. She earned both her M.S. and Ph.D. from the University of Washington School of Oceanography, modeling circulation variability in Puget Sound, Washington. She has been a AAAS Science and Technology Policy Fellow and a National Academies Science and Technology Policy Graduate Fellow.

Beverly Banister
Beverly is currently the Director of the Air, Pesticides and Toxics Management Division. She is responsible for planning, coordinating, and implementing all Regional EPA Air, Pesticides, and Toxics programs. She has been with EPA for more than 26 years and has extensive experience in many EPA programs and offices including EPA Headquarters. Beverly served as the Acting Deputy Regional Administrator at the EPA Region 4 from January 21, 2009, where she served until the appointment of the new Regional Administrator took place in September 2010. She has also provided management and leadership to both the Waste and Water Management Divisions. Beverly has been recognized with many awards for her knowledge, skills, and leadership abilities which produced environmental results. She was the recipient of the Federal Executive Board EPA All Star Award, the Donald J. Guinyard Pioneer Achievement Award, and the prestigious Lee M. Thomas Excellence in Management Award. In addition to these career achievements and honors, Beverly has provided leadership to numerous organizations within and outside EPA. Most recently, she has been appointed to serve on the Cross-EPA Climate Change Adaptation Workgroup focused on integrating climate change into all EPA activities. She is a graduate of Auburn University with a degree in Chemical Engineering.

Roel Boumans
Dr. Boumans is a special government employee for the United States Protection Agency. He received his doctorate degree as an ecosystem ecologist at the Department of Oceanography and Coastal Systems at Louisiana State University. His work as an estuarine ecologist inspired the Christmas tree fencing projects in Louisiana (http://dnr.louisiana.gov/crm/coastres/pcwrp/history.asp) and led to the development of the Surface Elevation Table (http://www.pwrc.usgs.gov/set/). Dr. Boumans is a pioneer in developing the concepts behind dynamic GIS systems modeling and has published several peer reviewed papers on the subject. Dr. Boumans joined the Institute of Ecological Economics as an Associate Research Scientist in 1996. His work at ISEE focused on processes from various ecosystems that take place at the landscape level within the Patuxent River watershed, and the development of landscape modeling protocol that largely makes use of computer technology to structure ecological data into a temporal and spatially relevant database structure. He moved with the ISEE to Vermont to work at the GUND Institute for Ecological Economics. As an ecological economist he has worked on issues concerning the conceptualization and valuation of ecosystem services and was the designer builder of the Global Unified Metamodel of the Biosphere (GUMBO). At present, Dr. Boumans is the Director for AFORDable Futures, a leader in the design and application of ecosystem based management tools to include the Multiscale Integrated Model of Ecosystem Services (MIMES). The Director of AFORDable Futures serves as a Special Government Employee for the US Environmental Protection Agency to help them forward their thinking on Ecosystem service. He also speaks on panels and teaches courses worldwide.

Marc Coudert
Marc Coudert is an Environmental Program Coordinator with the City of Austin Climate Protection Program. Before joining the City of Austin, Marc was an urban planner and intern architect for a variety of firms in California and Upstate New York. Marc also taught as an adjunct professor at the Rensselaer Polytechnic Institute School of Architecture where he lectured on issues of regional planning and sustainable urban design. Marc is currently managing the Community Climate Action Plan and is starting the conversation about climate adaptation with City departments, Austin Energy and the greater community. Marc holds a degree in Urban Planning from Arizona State University.

Thomas Fontaine
After earning his Ph.D. in Environmental Engineering Sciences from the University of Florida in 1978, Dr. Fontaine started his professional career as a scientist at the University of Georgia's Savannah River Ecology Laboratory. In 1983 he joined NOAA's Great Lakes Environmental Research Laboratory as a research program leader and collaborated extensively with the EPA and the International Joint Commission on solving Great Lakes contamination issues. Dr. Fontaine joined the South Florida Water Management District where he served from 1990 to 2001, first as Division Director for Water Quality, then for Everglades Research, and then as senior manager of the Environmental Monitoring and Assessment Department with oversight of three divisions. Dr. Fontaine joined the Federal Government's Senior Executive Service in 2001 when he was appointed Director the USEPA's Western Ecology Division. Dr. Fontaine specializes in systems ecology and modeling, research program development, and communication at the political and scientific interface. In Florida, he was a member of the Governor's Commission for a Sustainable South Florida Scientific Advisory Panel and received the National Audubon-American Association of Engineering Societies Palladium Medal for his team's efforts to provide the scientific and engineering foundation for Everglades restoration. He has been an invited panelist and speaker both nationally and internationally, has published widely, and is a founding (and current) member of the Editorial Board for the professional journal "Frontiers in Ecology and the Environment". In his current capacity as Director of EPA's Western Ecology Division he oversees research on ecosystem services in support of human well being; the influence of non-navigable streams and wetlands on navigable waters; the effects of alternate futures (as influenced by population growth, climate change and other factors) on salmon populations, water quality, and water quantity; research and development on monitoring designs and indicators for assessing freshwater and estuarine ecosystem condition and the effectiveness of agency actions; and the temporal and spatial effects of novel technologies (e.g. GM crops, nanomaterials, and pesticides) on terrestrial systems including wildlife.

Jim Fox
James (Jim) Fox is the Director for UNC Asheville's NEMAC (National Environmental Modeling and Analysis Center). In that position, he serves as the team leader and principal investigator for several major collaborations that deal with utilizing large environmental databases, spatial visualizations and other high end technologies to create products for decision making in complex situations. One project is in partnership with the US Forest Service Eastern Forest Environmental Threat Analysis Center (EFETAC) and addresses threats to our nations' forests. A second project is a partnership with NOAA's National Climatic Data Center that focuses on climate literacy education and providing data at a local scale for decision makers across a variety of sectors. A third project is the local engagement site for RENCI, the Renaissance Computing Institute for North Carolina. The center uses 3D visualizations, web tools and decision support tools to address climate change related issues that include flood mitigation, water resources and future land use planning. Jim holds undergraduate degrees in Geology/Geophysics and Communications and a Masters Degree in Information Technology for Informal Education. His passion is utilizing community collaborations and computer technologies to aid in complex decision making. Over the years, he has designed and taught many workshops with a foundation in hands-on learning through application of tools to real life problems. In addition, he has designed and installed exhibits at a collection of museums and National Parks nationwide.

Robert Horn
Robert E. Horn is a Visiting Scholar in the Human Sciences and Technology Advanced Research Institute (H-STAR) at Stanford University. Bob has innovated a new facilitated process that enables multidisciplinary task forces to better deal with complex problems. He calls this work the mapping of social messes. As a futurist and strategist, Horn has participated extensively with task forces to create scenarios, strategic plans, and organizations that can execute them. Unlike most, he does not write reports. Rather, he usually presents his results in the form of large information murals. He has worked with strategic planning on nuclear waste disposal (for the UK's government agency); climate change and energy security issues for the UK Foreign Office. In many of these engagements, he has created a form of mural that portrays the strategic context and future scenarios, the current decision-making issues, and the crucial interaction of the private and public sectors. He recently finished a 40-year backcasting mural for the World Business Council on Sustainable Development task force – Vision 2050. Horn pioneered the exploration and use of visual language (the tight integration of words and visual elements). He says in the subtitle of his book Visual Language, that this phenomenon is becoming a new form of "global

communication for the 21st century." He advanced the development of argumentation mapping in the 1990s by creating the largest “industrial strength” set of argumentation maps, thereby demonstrating conclusively that this methodology could handle questions of any size and complexity. In the field of simulation, he was the Editor-in-Chief of The Guide to Simulations/Games through four editions in the 1980s. He has taught at Harvard and Columbia universities. His consulting clients have included the Alberta Department of the Environment, Foresight Canada, International Futures Forum (UK), Boeing, AT&T, HP, and other Global 1000 companies. He is a fellow of the World Academy of Art and Science and is a Woodrow Wilson Fellow.

Drew Jones
Drew Jones is Co-Director of Climate Interactive, a Washington DC-based “think and do tank” that creates policy-maker-oriented simulations for top leaders and civil society. Trained in system dynamics modeling at Dartmouth College and MIT, Jones has worked at Rocky Mountain Institute and served dozens of clients ranging from the CDC to Harley Davidson to the U.S. Government Climate Change Negotiators. He and his team at CI and MIT Sloan developed “C-ROADS”, the user-friendly climate simulation in use by the U.S. State Department’s Jonathan Pershing, John Holdren in the White House, Senator John Kerry, and the analysts for the Chinese Government. He co-accepted the "ASysT Prize" for “a significant accomplishment achieved through the application of systems thinking to a problem of U.S. national significance." He teaches System Dynamics at the UNC Chapel Hill’s Kenan Flagler Business School.

Robyn Kenney
Robyn Kenney works in U.S. EPA's State Climate and Energy Program where she provides guidance and technical assistance to State and Local governments to help quantify greenhouse gas and criteria pollutant emission reductions as well as associated co-benefits. Prior to joining the U.S. EPA in January 2010, Robyn worked at the Ohio EPA Air Pollution Division, for over three years, where she developed and managed a state-wide Emission Reduction Credit Trade and Banking Program. She also provided greenhouse gas technical assistance to the public and regulated community as well as climate change policy analysis for Ohio EPA management. Robyn holds a B.A. in Environmental Science and a M.A. in Energy and Environmental Analysis from Boston University.

Dan Loughlin
Dan Loughlin is an environmental scientist with the U.S. EPA Office of Research and Development’s National Risk Management Laboratory (NRMRL). He has been with the EPA since 2003, having previously been a member of the research faculties of North Carolina State University and the University of North Carolina at Chapel Hill, as well as a consultant at MCNC. Dan earned a BS degree from Duke University, followed by masters and doctoral degrees in Civil Engineering from North Carolina State University. His specialty is systems analysis, including optimization, sensitivity and uncertainty analysis, data mining, model integration, and software development. Dan currently is a member of the NRMRL’s Energy and Climate Assessment Team, which is responsible for EPA’s MARKAL energy and emissions modeling efforts. He is using MARKAL to investigate potential long-term pollutant emissions trends considering alternative assumptions about population growth and migration, economic growth and transformation, land use change, climate change, technology change, behavior and policy.

George Luber
Dr. George Luber is an epidemiologist and the Associate Director for Climate Change in the Division of Environmental Hazards and Health Effects at the National Center for Environmental Health, CDC. Since receiving his PhD in Medical Anthropology from the University of Georgia, and joining CDC, Dr. Luber has served as an Epidemic Intelligence Service (EIS) Officer and staff epidemiologist at the National Center for Environmental Health. His research interests in Environmental Health are broad and include the health impacts of environmental change and biodiversity loss, harmful algal blooms, and the health effects of climate change. Most recently, his work has focused on the epidemiology and prevention of heat-related illness and death, the application of remote sensing techniques to modeling vulnerability to heat stress in urban environments, and Climate Change adaptation planning. In addition to managing the Climate Change Program at CDC, Dr. Luber is an agency representative to the US Global Change Research Program and is a lead author for the Intergovernmental Panel on Climate Change (IPCC), Fifth Assessment Report.

Mandy Schmitt Mahoney
Mandy is Director of Sustainability for the City of Atlanta. Working to be a more sustainable city means reconciling the city's developmental goals with its environmental limits over the long term. In order to do this, all city government operations are being filtered through the lens of ensuring that current levels of consumption can be maintained in perpetuity. Under Mandy's direction, the Division of Sustainability is improving the city's green programs and policies such as water and energy conservation, reducing solid waste and emissions and improving the rates of recycling. Implementing the City's first Sustainability Plan launched in October 2010, Mandy and her staff are working with all city departments to balance Atlanta's economic growth with environmental protection while being mindful of social justice. Mandy is proud that she was part of the team that launched the BeltLine. Other work experience includes Ahmann, Weeks Properties Group and the Georgia Department of Natural Resources. She serves on the Board of Directors for Georgia Organics, the Atlanta Chapter of Ducks Unlimited, Green Chamber of the South, Urban Sustainability Directors Network and the Caretta Environmental Leadership Award. She is a graduate of LEAD Atlanta 2010 and the Institute for Georgia Environmental Leadership 2010. Mandy has a master's degree in environmental management from Duke University. She also earned a law degree and a bachelor's degree in biology and environmental studies from Emory University.

Steve McNulty
Steve McNulty is the team leader of the Eastern Forest Environmental Threats Assessment Center located on the North Carolina State University campus in Raleigh North Carolina. Dr. McNulty is a landscape ecologist with a Ph.D. in Natural Resources from the University of New Hampshire. His area of focus is regional to continental scale environmental stress impact modeling on forest ecosystems. He served as a US Congressional Fellow in the 106th Congress, and he was the federal chair of the National Assessment of Climate Change Impacts on US Forests. Dr. McNulty has authored or co-authored over 150 papers in the area of environmental stress impacts on forest ecosystems.

David Meriwether
David Meriwether is the Regional Ecosystem Management Coordinator for the Southern Region of the US Forest Service in Atlanta, GA. David is a biological scientist on the Regional Planning Staff, with responsibility for the inventory and monitoring program for the region and climate change coordination for the national forest system. He served in many land management, planning and information management positions, including several national forests and regional positions.

Andy Miller
C. Andrew (Andy) Miller is the Acting National Program Director for Global Change Research with EPA's Office of Research and Development (ORD). Andy has been with ORD for 20 years, with much of his research focused on characterization and control of combustion-generated air pollution. In his previous position, Andy led a group of researchers evaluating the environmental implications – including GHG emissions – of changes in the U.S. energy system resulting from changes in technology and policy using the MARKAL energy systems model. Andy has served as the research program leader for National Risk Management Research Laboratory's PM characterization and control program and as technical lead for the NRMRL Biofuel/Bioenergy research team, and was Acting National Program Director for ORD's PM research program. He is Chair of the American Society of Mechanical Engineers' Carbon Sequestration Committee and a member of the United Engineering Foundation Founder Society's Carbon Measurement Team. He received a B.S. and M.S. in mechanical engineering from the University of Arizona, and a Ph.D. in mechanical engineering from North Carolina State University, and is a registered Professional Engineer in North Carolina.

Phil Morefield
Phil Morefield has been a geographer for the National Center for Environmental Assessment's Global Change Research Program for more than two years. A primary focus during that time has been the development of the Integrated Climate and Land-Use Scenarios project as a GIS based modeling tool. Recent topics of interest include developing nationwide scenarios of vulnerability to environmental change and the creation GIS tools for processing climate model output.

Joel Scheraga
Dr. Joel Scheraga is the Senior Advisor for Climate Adaptation in EPA's Office of Policy in the Office of the Administrator. He is helping EPA integrate considerations of climate change into its programs and rules to ensure they are effective under future climatic conditions. He is leading EPA's new Work Group on Climate Change Adaptation Planning which is charged with developing and implementing a climate change adaptation plan for the Agency. He also represents EPA on the federal Interagency Climate Change Adaptation Task Force, established by Executive Order in October 2009 to develop recommendations for President Obama on how the nation might adapt to climate change impacts. Prior to assuming his current position, Scheraga served as the National Program Director for EPA's Global Change Research Program in the Office of Research and Development from 1998-2009. Scheraga has published numerous articles on climate change science and policy, environmental economics, the integration of science and policy, and applied microeconomics and microeconomic theory. He participated in the Intergovernmental Panel on Climate Change (IPCC), which was awarded the 2007 Nobel Peace Prize. Scheraga received an A.B. degree in geology-mathematics/physics from Brown University in 1976, an M.A. in economics from Brown University in 1979, and a Ph.D. in economics from Brown University in 1981.

Michael Simpson
Michael Simpson has been actively working and teaching in the watershed management and wetlands research fields for over twenty-five years. He has graduate degrees from both Dartmouth College and Antioch New England Graduate School. At Antioch New England University, he serves as the Chair of the Environmental Studies Department where he teaches graduate level courses in wetlands ecology, watershed management, environmental site assessment and economic analysis of policy decisions. He is a certified wetlands scientist within the State of New Hampshire. He has conducted numerous delineations and wetland assessments, employing a variety of assessment approaches and data collection procedures. His primary research focuses upon impact to riparian corridors and estuaries, from changes in land-use combined with increases in storm intensity and frequency due to projected climate change. He also has conducted numerous economic cost/avoided cost analyses related to decisions regarding resource utilization and conservation. He is currently working under three NOAA funded grants that identify potential risk from projected climate and land-use change and includes development of effective strategies to both communicate science and risk to stakeholders and to facilitate local adaptation decisions.

Raghavan Srinivasan
Dr. Raghavan Srinivasan (TAMU) is the Director of Texas A&M University's Spatial Sciences Laboratory. He is also a professor in the Departments of Ecosystem Science and Management and Biological and Agricultural Engineering at TAMU. Dr. Srinivasan has more than 20 years experience in hydrologic, hydraulic, and water quality modeling. Dr. R. Srinivasan has developed the interfaces to make use of water quality models like SWAT on various GIS platforms such as GRASS and ARCVIEW. He was involved in integrating SWAT as one of the water quality models into EPA's BASINS framework. Dr. Srinivasan has also developed spatial tools on automated watershed delineation, land use soil definitions for subwatersheds, and calibration for BASINS. He has also been involved in evaluating the pesticide components of SWAT for EPA. Dr. Srinivasan has headed many watershed quality related projects involving watershed modeling, water quality assessment, and development of BMPs and evaluating long-term impacts of BMPs. He has headed continental scale projects (HUMUS and HAWQS), which provided information for 1997 RCA analysis of USDA and EPA respectively. He has served in several water related committees at State and National levels including project works review committees for EPA.

Background Information

Community of Practice for Integrated Environmental Modeling

Building on the successful CREM Integrated Modeling Workshops (2007 and 2008), the CREM has catalyzed the development of an international community of practice to bring together scientists and technologists to share knowledge, resolve science and technology issues related to integrated environmental modeling, and provide solutions to decision makers. Since the 2008 CREM Integrated Modeling Workshop, a large number of collaborators from federal agencies, academia and international organizations have met regularly to develop the Community of Practice for Integrated Environmental Modeling (CIEM) and determine the functionalities that will be useful in its web-portal.

The web-portal (**iemHUB**) is currently under development and was launched at the International Environmental Modeling and Software Society Conference in July 2010. The iemHUB is envisioned to be the place for the integrated environmental modeling community to come together and share information. It will include an interactive tool repository, where community members may upload, share and run models and modeling support tools. It will also include multiple ways for community members to interact and collaborate and share expertise. The features of the iemHUB include:

- Model and Tool Repository
- Collaborative model development groups
- A Subversion repository for model development and version control
- Documents Library
- Training and Technical Support Tools
- Community Support Forum
- Job and grants announcements board

We invite interested participants or those interested in collaborating on integrated modeling projects to join the community and make use of the iemHUB via the following URL: http://www.iemhub.org

For more information, please call or email Noha Gaber (202-564-2179 gaber.noha@epa.gov)

Global Climate Change Impacts in the United States

U.S. Global Change Research Program

Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009.
http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts/download-the-report

This report summarizes the science of climate change and the impacts of climate change on the United States, now and in the future. It is largely based on results of the U.S. Global Change Research Program (USGCRP), and integrates those results with related research from around the world. This report discusses climate-related impacts for various societal and environmental sectors and regions across the nation. It is an authoritative scientific report written in plain language, with the goal of better informing public and private decision making at all levels.

KEY FINDINGS FROM THE REPORT: *(detailed descriptions available in the full text)*

- Global warming is unequivocal and primarily human-induced.
- Climate changes are underway in the United States and are projected to grow.
- Widespread climate-related impacts are occurring now and are expected to increase.
- Climate change will stress water resources.
- Crop and livestock production will be increasingly challenged.
- Coastal areas are at increasing risk from sea-level rise and storm surge.
- Risks to human health will increase.
- Climate change will interact with many social and environmental stresses.
- Thresholds will be crossed, leading to large changes in climate and ecosystems.
- Future climate change and its impacts depend on choices made today.

SECTOR IMPACTS OF CLIMATE CHANGE

Adapted from:
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Water Resources

- Climate change will affect where, when, and how much water is available for all uses.
- Floods and droughts are likely to become more common and more intense as regional and seasonal precipitation patterns change, and rainfall becomes more concentrated into heavy events (with longer, hotter dry periods in between).
- Precipitation and runoff are likely to increase in the Northeast and Midwest in winter and spring, and decrease in the West, especially the Southwest, in spring and summer.
- In areas where snowpack dominates, the timing of runoff will continue to shift to earlier in the spring and flows will be lower in late summer.
- Surface water quality and groundwater quantity will be affected by a changing climate.

Energy Supply and Use

- Warming will be accompanied by decreases in demand for heating energy and increases in demand for cooling energy. The latter will result in significant increases in electricity use and higher peak demand in most regions.
- Energy production is likely to be constrained by rising temperatures and limited water supplies in many regions.
- Energy production and delivery systems are exposed to sea-level rise and extreme weather events in vulnerable regions.
- Climate change is likely to affect some renewable energy sources across the nation, such as hydropower production in regions subject to changing patterns of precipitation or snowmelt.

Transportation

- Sea-level rise and storm surge will increase the risk of major coastal impacts, including both temporary and permanent flooding of airports, roads, rail lines, and tunnels.
- Flooding from increasingly intense downpours will increase the risk of disruptions and delays in air, rail, and road transportation, and damage from mudslides in some areas.
- The increase in extreme heat will limit some transportation operations and cause pavement and track damage. Decreased extreme cold will provide some benefits such as reduced snow and ice removal costs.
- Increased intensity of strong hurricanes would lead to more evacuations, infrastructure damage and failure, and transportation interruptions.
- Arctic warming will continue to reduce sea ice, lengthening the ocean transport season, but also resulting in greater coastal erosion due to waves.
- Permafrost thaw in Alaska will damage infrastructure. The ice road season will become shorter.

Agriculture

- Many crops show positive responses to elevated carbon dioxide and low levels of warming, but higher levels of warming often negatively affect growth and yields.
- Extreme events are likely to reduce crop yields because excesses or deficits of water have negative impacts on plant growth.
- Weeds, diseases, and insect pests benefit from warming, and weeds also benefit from a higher carbon dioxide concentration, increasing stress on crop plants and requiring more attention to pest and weed control.
- Forage quality in pastures and rangelands generally declines with increasing carbon dioxide concentration because of the effects on plant nitrogen and protein content.
- Increased heat, disease, and weather extremes are likely to reduce livestock productivity.

Ecosystems

- Ecosystem processes have been affected by climate change.
- Large-scale shifts have occurred in the ranges of species and the timing of the seasons and animal migration, and are very likely to continue.
- Fires, insect pests, disease pathogens, and invasive weed species have increased.
- Deserts and drylands are likely to become hotter and drier, feeding a self-reinforcing cycle of invasive plants, fire, and erosion.
- Coastal and near-shore ecosystems are already under multiple stresses. Climate change and ocean acidification will exacerbate these stresses.
- Arctic sea ice ecosystems are already being adversely affected by the loss of summer sea ice and further changes are expected.
- The habitats of some mountain species and coldwater fish, such as salmon and trout, are very likely to contract in response to warming.
- Some of the benefits ecosystems provide will be threatened others will be enhanced by climate change.

Human Health

- Increases in the risk of illness and death related to extreme heat and heat waves are very likely. Some reduction in the risk of death related to extreme cold is expected.
- Warming is likely to make it more challenging to meet air quality standards necessary
- Extreme weather events (projected to increase) cause physical and mental health problems.
- Some diseases transmitted by food, water, and insects are likely to increase.
- Rising temperature and carbon dioxide concentration increase pollen production and prolong the pollen season in a number of plants with highly allergenic pollen, presenting a health risk.
- Certain groups (children, elderly, and the poor) are most vulnerable to climate-related health effects.

Society

- Population shifts and development choices are making more Americans vulnerable to the expected impacts of climate change.
- Vulnerability is greater for those who have few resources and few choices.
- City residents and city infrastructure have unique vulnerabilities to climate change.
- Climate change affects communities through changes in climate-sensitive resources that occur both locally and at great distances.
- Insurance is one of the industries particularly vulnerable to increasing extreme weather events such as severe storms, but it can also help society manage the risks.
- The United States is connected to a world that is unevenly vulnerable to climate change and thus will be affected by impacts in other parts of the world.

Integrated Themes of Water-Related Impacts by Sector

Sector	Examples of Water-Related Impacts
Human Health	Heavy downpours increase incidence of waterborne disease and floods, resulting in potential hazards to human life and health.
Energy Supply and Use	Hydropower production is reduced due to low flows in some regions. Power generation is reduced in fossil fuel and nuclear plants due to increased water temperatures and reduced cooling water availability.
Transportation	Floods and droughts disrupt transportation. Heavy downpours affect harbor infrastructure and inland waterways. Declining Great Lakes levels reduce freight capacity.
Agriculture and Forests	Intense precipitation can delay spring planting and damage crops. Earlier spring snowmelt leads to increased number of forest fires.
Ecosystems	Coldwater fish threatened by rising water temperatures (due to decreased watershed precipitation).

REGIONAL IMPACTS OF CLIMATE CHANGE

Adapted from:

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Northeast

- Extreme heat and declining air quality are likely to pose increasing problems for human health, especially in urban areas.
- Agricultural production, including dairy, fruit, and maple syrup, are likely to be adversely affected as favorable climates shift.
- Severe flooding due to sea-level rise and heavy downpours is likely to occur more frequently.
- The projected reduction in snow cover will adversely affect winter recreation and the industries that rely upon it.
- The center of lobster fisheries is projected to continue its northward shift and the cod fishery on Georges Bank is likely to be diminished.

Southeast

- Projected increases in air and water temperatures will cause heat-related stresses for people, plants, and animals.
- Decreased water availability is very likely to affect the region's economy as well as its natural systems.
- Ecological thresholds are expected to be crossed throughout the region, causing major disruptions to ecosystems and to the benefits they provide to people.
- Quality of life will be affected by increasing heat stress, water scarcity, severe weather events, and reduced availability of insurance for at-risk properties.

Midwest

- During the summer, public health and quality of life, especially in cities, will be negatively affected by increasing heat waves, reduced air quality, and insect and waterborne diseases. In the winter, warming will have mixed impacts.
- Significant reductions in Great Lakes water levels, which are projected under higher emissions scenarios, lead to impacts on shipping, infrastructure, beaches, and ecosystems.
- The likely increase in precipitation in winter and spring, more heavy downpours, and greater evaporation in summer would lead to more periods of both floods and water deficits.
- While the longer growing season provides the potential for increased crop yields, increases in heat waves, floods, droughts, insects, and weeds will present increasing challenges to managing crops, livestock, and forests.
- Native species are very likely to face increasing threats from rapidly changing climate conditions, pests, diseases, and invasive species moving in from warmer regions.

Great Plains

- Projected increases in temperature, evaporation, and drought frequency add to concerns about the region's declining water resources.
- Agriculture, ranching, and natural lands, already under pressure due to an increasingly limited water supply, are very likely to also be stressed by rising temperatures.
- Climate change is likely to affect native plant and animal species by altering key habitats such as the wetland ecosystems known as prairie potholes or playa lakes.
- Ongoing shifts in the region's population from rural areas to urban centers will interact with a changing climate, resulting in a variety of consequences.

Southwest

- Water supplies are projected to become increasingly scarce, calling for trade-offs among competing uses, and potentially leading to conflict.
- Increasing temperature, drought, wildfire, and invasive species will accelerate transformation of the landscape.
- Increased frequency and altered timing of flooding will increase risks to people, ecosystems, and infrastructure.
- Unique tourism and recreation opportunities are likely to suffer.
- Cities and agriculture face increasing risks from a changing climate.

Northwest

- Declining springtime snowpack leads to reduced summer streamflows, straining water supplies.
- Increased insect outbreaks, wildfires, and changing species composition in forests will pose challenges for ecosystems and the forest products industry.
- Salmon and other coldwater species will experience additional stresses as a result of rising water temperatures and declining summer streamflows.
- Sea-level rise along vulnerable coastlines will result in increased erosion and the loss of land.

Alaska

- Longer summers and higher temperatures are causing drier conditions, even in the absence of strong trends in precipitation.
- Insect outbreaks and wildfires are increasing with warming.
- Lakes are declining in area.
- Thawing permafrost damages roads, runways, water and sewer systems, and other infrastructure.
- Coastal storms increase risks to villages and fishing fleets.
- Displacement of marine species will affect key fisheries.

Islands

- The availability of freshwater is likely to be reduced, with significant implications for island communities, economies, and resources.
- Island communities, infrastructure, and ecosystems are vulnerable to coastal inundation due to sea-level rise and coastal storms.
- Climate changes affecting coastal and marine ecosystems will have major implications for tourism and fisheries.

Coasts

- Significant sea-level rise and storm surge will adversely affect coastal cities and ecosystems around the nation; low-lying and subsiding areas are most vulnerable.
- More spring runoff and warmer coastal waters will increase the seasonal reduction in oxygen resulting from excess nitrogen from agriculture.
- Higher water temperatures and ocean acidification due to increasing atmospheric carbon dioxide will present major additional stresses to coral reefs, resulting in significant dieoffs and limited recovery.
- Changing ocean currents will affect coastal ecosystems.

Advancing the Science of Climate Change:

America's Climate Choices

National Research Council

National Academies Press, Washington, D.C. 2010

http://www.nap.edu/catalog.php?record_id=12782

This report reviews the current scientific evidence regarding climate change and examines the status of the nation's scientific research efforts. It also describes the critical role that climate change science, broadly defined, can play in developing knowledge and tools to assist decision makers as they act to respond to climate change. The report explores seven crosscutting research themes that should be included in the nation's climate change research enterprise and recommends a number of actions to advance the science of climate change – a science that includes, and increasingly integrates, across the physical, biological, social, health, and engineering sciences. Overall, the report concludes that:

1. Climate change is occurring, is caused largely by human activities, and poses significant risks for a broad range of human and natural systems; and
2. The nation needs a comprehensive and integrated climate change science enterprise, one that not only contributes to our fundamental understanding of climate change but also informs and expands America's climate choices.

RECOMMENDATIONS FROM THE REPORT:

- The nation's climate change research enterprise should include and integrate disciplinary and interdisciplinary research across the physical, social, biological, health, and engineering sciences; focus on fundamental, use-inspired research that contributes to both improved understanding and more effective decision making; and be flexible in pursuing emerging research challenges.
- Research priorities for the federal climate change research program should be set within each of the seven crosscutting research themes outlined [in the report]. Priorities should be set using the following three criteria: (1) Contribution to improved understanding; (2) Contribution to improved decision making; and (3) Feasibility of implementation, including scientific readiness and cost.
- The federal climate change research program, working in partnership with other relevant domestic and international bodies, should redouble efforts to design, deploy, and maintain a comprehensive observing system that can support all aspects of understanding and responding to climate change.
- The federal climate change research program should work with the international research community and other relevant partners to support and develop advanced models and other analytical tools to improve understanding and assist in decision making related to climate change.
- A single federal entity should be given the authority and resources to coordinate and implement an integrated research effort that supports improving both understanding of and responses to climate change. If key modifications are made, the US Global Change Research Program could serve this role.
- The federal climate change research program should be formally linked with action-oriented response programs focused on limiting the magnitude of future climate change, adapting to the impacts of climate change, and informing climate-related actions and decisions, and, where relevant, should develop partnerships with other research and decision-making entities working at local to international scales.
- Congress, federal agencies, and the federal climate change research program should work with other relevant partners (including universities, state and local governments, the international research community, the business community, and other nongovernmental organizations) to expand and engage the human capital needed to carry out climate change research and response programs.

CROSSCUTTING (INTEGRATED) THEMES AND NEEDS FOR THE NEW

Research to Improve Understanding of Human-Environment Systems

1. **Climate Forcings, Feedbacks, Responses, and Thresholds in the Earth System**
   - Extend understanding of natural climate variability on a wide range of space and time scales
   - Improve understanding of transient climate change (CC) and its dependence on ocean circulation, heat transport, mixing processes, and other factors, especially in the context of decadal-scale CC.
   - Improve estimates of climate sensitivity (theoretical, modeling, and observationally based approaches)
   - Expand observations and understanding of aerosols, especially their radiative forcing effects and implications for strategies that might be taken to limit the magnitude of future CC;
   - Improve understanding of cloud processes, and cloud-aerosol interactions, especially in the context of radiative forcing, climate feedbacks, and precipitation processes.
   - Improve understanding of ice sheets including the mechanisms, causes, dynamics, and relative likelihood of ice sheet collapse versus ice sheet melting.
   - Advance understanding of thresholds and abrupt changes in the Earth system.
   - Expand understanding of carbon cycle processes and feedbacks in the context of CC.
   - Improve understanding of ocean dynamics and regional rates of sea level rise.
   - Improve understanding of the hydrologic cycle, especially changes in the frequency and intensity of precipitation and feedbacks of human water use on climate.
   - Improve understanding and models of how agricultural crops, fisheries, and natural and managed ecosystems respond to CC (temperature, precipitation, CO2 levels, ocean acidification, etc.)

2. **Climate-related Human Behaviors and Institutions**
   - Improve understanding of water-related institutions and governance.
   - Improve understanding of human behaviors and institutional and behavioral impediments to reducing energy demand and adopting energy-efficient technologies.
   - Improve understanding of what leads to the adoption and implementation of international agreements on climate and what forms of such agreements most effectively achieve their goals.
   - Improve understanding of how institutions interact in the context of multilevel governance and adaptive management.
   - Improve understanding of the behaviors, infrastructure, and technologies that influence human activities in the transportation, urban, agricultural, fisheries, and other sectors.
   - Improve understanding of the relationship between CC and institutional responses that affect national security, food security, health, and other aspects of social well-being.

Research to Support Effective Responses to Climate Change (CC)

3. Vulnerability and Adaptation Analyses of Coupled Human-Environment Systems

- Expand the ability to identify and assess vulnerable coastal regions and populations and to develop and assess adaptation strategies, including barriers to their implementation.
- Assess food security and vulnerability of food production and distribution systems to CC impacts, and develop adaptation approaches.
- Develop and improve technologies, management strategies, and institutions to enhance adaptation to CC in agriculture and fisheries.
- Develop vulnerability assessments and integrative management approaches and technologies to respond effectively to changes in water resources.
- Assess vulnerabilities of ecosystems and ecosystem services to CC.
- Assess current and projected health risks associated with CC and develop effective, efficient, and fair adaptation measures.
- Assess the vulnerability of cities and other parts of the built environment to CC, and develop methods for adapting.
- Advance understanding of how CC will affect transportation systems and how to reduce vulnerability to these impacts.
- Develop improved vulnerability assessments for regions of importance in terms of military operations and infrastructure.

4. Research to Support Strategies for Limiting Climate Change

- Advance the development, deployment, and adoption of energy and transportation technologies that reduce GHG emissions.
- Develop and evaluate strategies for promoting the use of less-emission-intensive modes of transportation.
- Characterize and quantify the contributions of urban areas to both local and global changes in climate, and develop and test approaches for limiting these contributions.
- Continue to support efforts to improve energy efficiency in all sectors and develop a better understanding of the obstacles to improved efficiency.
- Improve understanding of behavioral and sociological factors related to the adoption of new technologies, policies, and practices.
- Develop and improve integrated approaches for evaluating energy services in a systems context that accounts for a broad range of societal and environmental concerns, including CC.
- Develop and improve technologies, management strategies, and institutions to reduce net GHG emissions from agriculture, while maintaining or enhancing food production potential.
- Assess the potential of land, freshwater, and ocean ecosystems to increase net uptake of GHG and develop approaches that could take advantage of this potential without major adverse consequences.
- Improve understanding of links between air quality and CC and develop strategies that can limit the magnitude of CC while improving air quality.
- Establish and maintain monitoring systems capable of supporting evaluations of actions and strategies taken to limit the magnitude of future CC, including systems that can verify compliance with international GHG emissions-reduction agreements.

5. Effective Information and Decision-Support Systems

- Develop a comprehensive and integrative understanding of factors that influence decision making.
- Improve knowledge and decision-support capabilities for all levels of governance in response to the challenges associated with sea level rise.
- Develop effective decision-support tools and approaches for decision making under uncertainty, especially when multiple governance units may be involved, for water resource management, food and fiber production issues, urban and human health issues, and other key sectors.
- Develop protocols, institutions, and technologies for monitoring and verifying compliance with international climate agreements.
- Measure and evaluate public attitudes and test communication approaches that most effectively inform and engage the public in climate-related decision making.

Research Tools and Approaches to Improve Both Understanding and Responses

6. Integrated Climate Observing Systems

- Extend and expand long-term observations of atmosphere and ocean temperatures; sea level; ice extent, mass, and volume; and other critical physical climate system variables.
- Extend and expand long-term observations of hydrologic changes and related changes relevant for water management decision making.
- Expand observing and monitoring systems for ecosystems, agriculture and fisheries, air and water quality, and other critical impact areas.
- Improve observations that allow analysis of multiple stressors, including changes in climate, land use changes, pollutant deposition, invasions of nonnative species, and other human-caused changes.
- Develop improved observations and monitoring capabilities to support vulnerability assessments of coupled human-environment systems at the scale of cities, states, nations, and regions, and for tracking and analyzing human health and well-being.
- Develop improved observations for vulnerability assessments related to military operations and infrastructure.
- Establish long-term monitoring systems that are capable of monitoring and assessing the effectiveness of actions taken to limit or adapt to climate change (CC).
- Develop observations, protocols, and technologies for monitoring and verifying compliance with international emissions-reduction agreements.

7. Improved Projections, Analyses, and Assessments

- Continue to develop and use scenarios as a tool for framing uncertainty and risk, understanding human drivers of CC, forcing climate models, and projecting changes in adaptive capacity and vulnerability.
- Improve model projections of future CC, especially at regional scales.
- Improve end-to-end models through coordination and linkages among models that connect emissions, changes in the climate system, and impacts on specific sectors.
- Develop tools and approaches for understanding and predicting the impacts of sea level rise on coastal ecosystems and infrastructure.
- Improve models of the response of agricultural crops, fisheries, transportation systems, and other human systems to climate and other environmental changes.
- Develop integrated approaches and analytical frameworks to evaluate the effectiveness and potential unintended consequences of actions taken to respond to CC, including trade-offs and synergies among various options.
- Explore cross-sector interactions between impacts of and responses to CC.
- Continue to improve methods for estimating costs, benefits, and cost effectiveness of climate mitigation and adaptation policies, including complex or hybrid policies.
- Develop analyses that examine climate policy from a sustainability perspective, taking account of the full range of effects of climate policy on human and environmental systems, including unintended consequences and equity effects.

The White House Council on Environmental Quality

Progress Report of the Interagency Climate Change Adaptation Task Force: Recommended Actions in Support of a National Climate Change Adaptation Strategy

October 5, 2010

http://www.whitehouse.gov/sites/default/files/microsites/ceq/Interagency-Climate-Change-Adaptation-Progress-Report.pdf

Summary of Policy Goals and Recommended Actions for the Federal Government

1. **Encourage and Mainstream Adaptation Planning across the Federal Government** – Climate change will challenge the mission, operations, and programs of nearly every Federal agency. Ensuring that the Federal Government has the capacity to execute its missions and maintain important services in the face of climate change is essential.

2. **Improve Integration of Science into Decision Making** – Access to integrated, interdisciplinary science is critical to understanding potential climate change impacts, and informing the development, implementation and evaluation of response strategies.

3. **Address Key Cross Cutting Issues** – The breadth of certain climate change impacts creates challenges that cut across the jurisdictions and missions of individual Federal agencies. Addressing these issues will require a collaborative approach along with coordination and partnerships at the local, state, Tribal, and regional levels.

4. **Enhance Efforts to Lead and Support International Adaptation** – Climate change poses risks and opportunities that are important to many of the U.S. Government's international development, security, and diplomatic priorities. Climate change adaptation should be a core consideration in the design and implementation of U.S. foreign assistance activities. Agencies should enhance collaboration to support international adaptation objectives.

5. **Coordinate Capabilities of the Federal Government to Support Adaptation** – The Federal Government should improve coordination of its science, services, and assessments to better support stakeholders.

Adapting to the Impacts of Climate Change:

America's Climate Choices

National Research Council

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http://www.nap.edu/catalog.php?record_id=12782

In order to address the challenges associated with climate change, Congress directed the National Research Council to "investigate and study the serious and sweeping issues relating to global climate change and make recommendations regarding the steps that must be taken and what strategies must be adopted in response to global climate change." As part of the response to this request, the America's Climate Choices Panel on Adapting to the Impacts of Climate Change was charged to "describe, analyze, and assess actions and strategies to reduce vulnerabilities, increase adaptive capacity, improve resilience, and promote successful adaptation to climate change in different regions, sectors, systems, and populations."