U.S. Climate Change Science Program Workshop

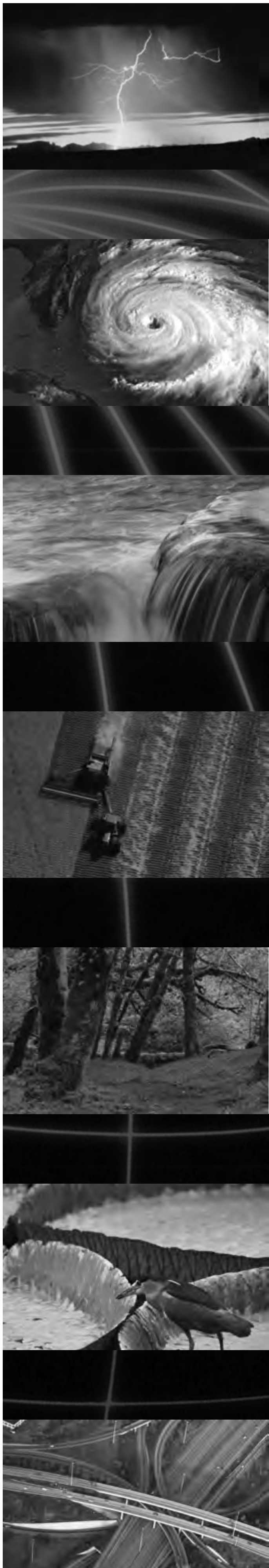
Climate Science in Support of Decision Making

Abstract Book

Crystal Gateway Marriott
Arlington, Virginia
14-16 November 2005

Poster Session Legend

Maroon	Decision Support: Processes and Products (P-DS)
Yellow	Food Production (P-FP)
Green	Ecosystems (P-EC)
Black	Carbon (P-CA)
Light blue	Coastal (P-CO)
Blue	Water and Energy (P-WE)
Purple	Air Quality and Health (P-AQ)
Red	General Climate Science (P-GC)



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Workshop Steering Committee

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The following pages contain abstracts for presentations given during U.S. Climate Change Science Program (CCSP) Workshop on Climate Science in Support of Decision Making, held November 14-16, 2005, at the Crystal Gateway Marriott Hotel in Arlington, Virginia. These abstracts represent the collected work of hundreds of climate researchers; experts in related technical fields; managers of resources affected by climate variability and change; regional, state, and local government officials; policy analysts; and other stakeholders.

The workshop was designed to serve as a forum to address progress and future plans for CCSP's three decision-support approaches: 1) prepare scientific syntheses and assessments on key climate science issues; 2) develop and illustrate adaptive management and planning capabilities; and 3) develop and evaluate information and methods to support climate change policymaking. The workshop examined the "state-of-the-art" in each of these three approaches through dialogues between producers of scientific information on climate variability and change and those who could use this information in decision making.

On July 1, 2005, a call went out for presentations that explore the application of information developed through science and technology research on climate variability and change to support decision making in the following five broad areas:

- *Water*, including drought, water supply and water quality, and the uses of water in agriculture, ecosystems, recreation, and other sectors;
- *Ecosystems*, including carbon sequestration, fire and other disturbances, invasive species, managed ecosystems (e.g., agriculture, forestry), and public health;
- *Coastal Issues*, including sea-level rise, infrastructure, storms, and marine resources;
- *Energy*, including climate information that supports energy management and seasonal forecasting, infrastructure, energy planning such as biomass and renewables; and
- *Air Quality*, including human health effects such as air quality and temperature issues.

Presentations were to address one or more of the following topics: the type of information that decision makers and other stakeholders need to inform decision making; evaluation of the current state of observations, modeling, or other research and its appropriateness for use in decision making at different scales; example applications of scientific information to support decision making; participant experiences; methods for communicating scientific information, including incorporation of information about levels of confidence and uncertainty in decision making; methods and metrics for evaluating outcomes; and opportunities for improved application of currently-available information and priorities for future CCSP research.

We received a great number of outstanding abstracts and gave careful consideration to each of them. Committees of agency scientists and program managers working in the five broad areas addressed in our call for presentations reviewed the abstracts and recommended which to accept primarily on the basis of relevance to CCSP and workshop objectives. Because so many strong abstracts were submitted, the Workshop Steering Committee scheduled a special evening poster session in which many of those abstracts not accepted as presentations could be discussed informally by workshop participants and additional guests. Of the nearly 300 abstracts received, more than 200 were accepted by the Workshop Steering Committee as either speaker or poster presentations.

Presenters were given an opportunity to submit revised abstracts for inclusion into this abstract book. Other than copyediting and formatting changes, these abstracts appear as they were received. The views expressed in these abstracts, and in the presentations they represent, are not those of the CCSP, its member agencies, or the U.S. Government.

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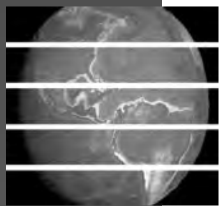

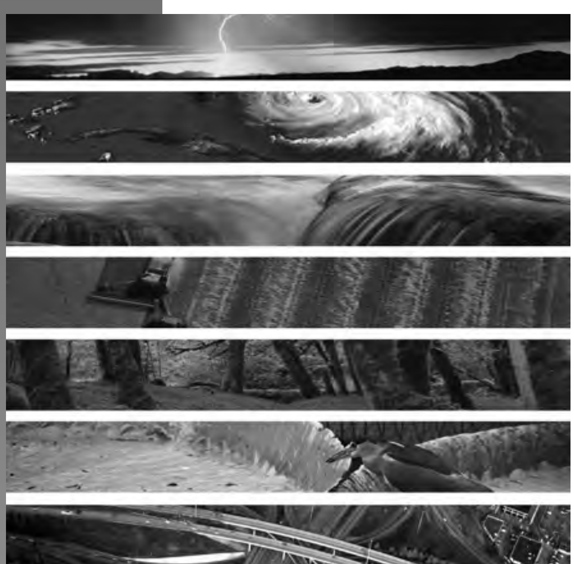

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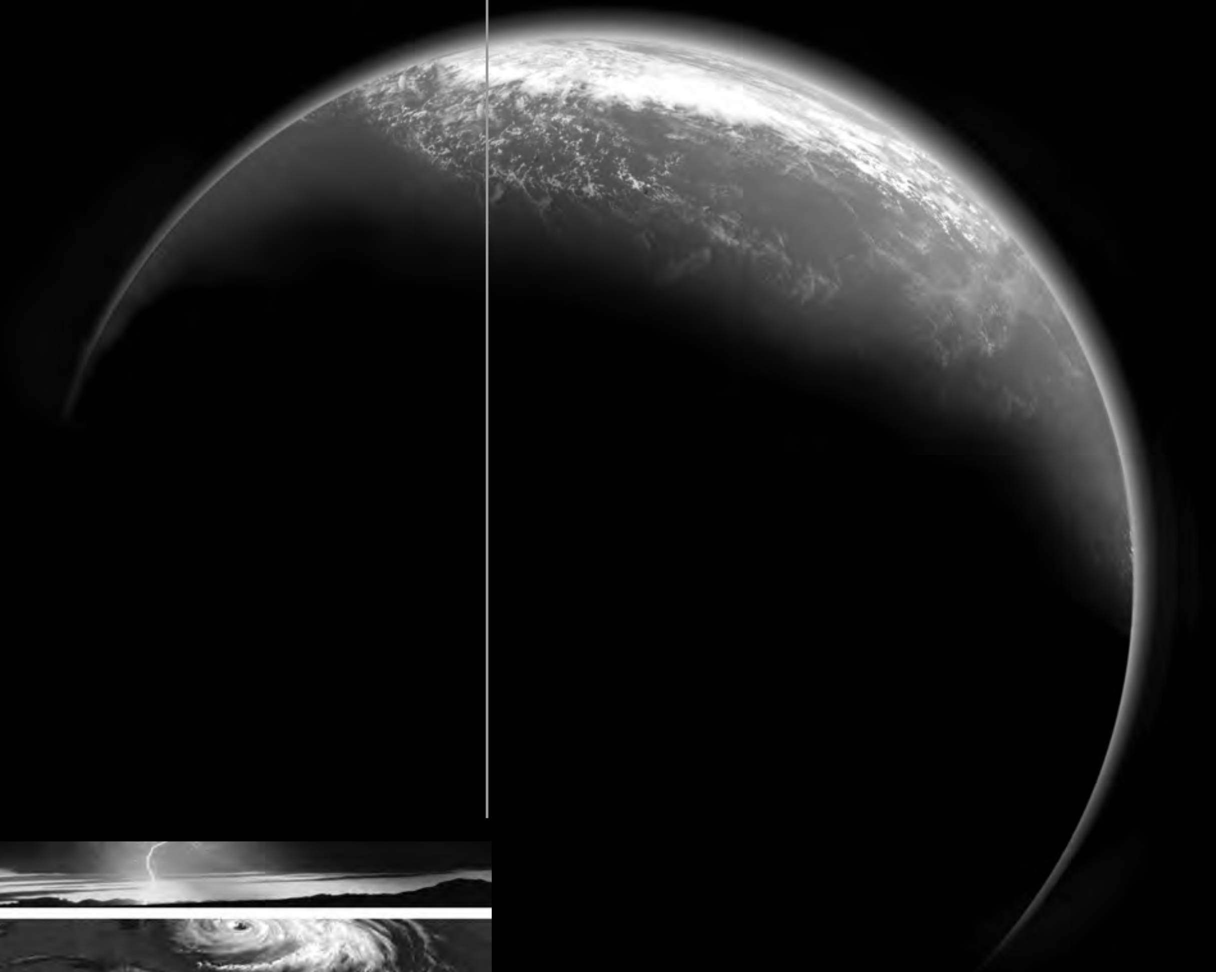

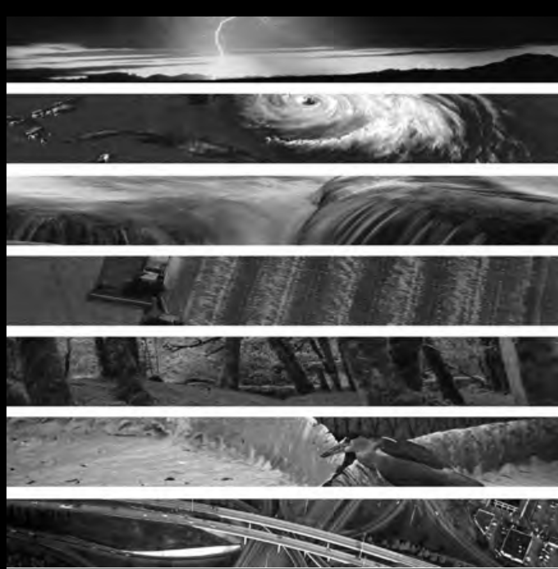

List of Speaker Abstract Titles and Authors

Abstracts for Speakers: Session 4

	Abstract Title	Authors
	Water Management: Application of Climate Science (WA) Sub-Theme 1: Water Supply Science and Information Needs	
WA1.1	Droughts and Floods: Better Predictions thru Attribution	Martin Hoerling
WA1.2	Climate in Three Dimensions: Integrated Mountain Climate Observations	Kelly Redmond
WA1.3	Climate Forecasts and Reservoir Management – Possibilities and Challenges	Sankar Arumugam, Upmanu Lall, Casey Brown, Neil Ward
WA1.4	Experiences from the Water Resources and Agricultural Sectors during Drought: What Do Users Want? What Do Researchers Want? What is Needed?	R. Webb, R. Pulwarty, D. Kenney, S. Jain, A. Ray, B. Udall, K. Wolter
WA1.5	Managing Seattle's Water Supply in Step with a Changing Climate	Daniel Basketfield
	Water Management: Application of Climate Science (WA) Sub-Theme 2: Climate-Related Decision Support for Water Allocation Use	
WA2.1	A RISA Success Story-The Southeast Climate Consortium	James J. O'Brien
WA2.2	Users Making Decisions for Water Allocation	Eric Kuhn
WA2.3	Walking the Talk: RISA Drought Insights for CCSP	Gregg Garfin, Greg Carbone, Dan Cayan, Keith Ingram, Philip Mote, Eileen Shea, Brad Udall
WA2.4	Robust Adaptation Decisions amid Climate Change Uncertainties	Suraje Dessai, Mike Hulme
WA2.5	Adapting New York City's Water Supply and Wastewater Treatment Systems to Climate Change	Emily Lloyd, David C. Major, Cynthia Rosenzweig, Kate Demong, Christina Stanton
	Ecosystems Management: Application of Climate Science (EC) Ecosystems Decision Support and Adaptive Responses	
EC1.1	The Role of Climate Science in U.S. Crop Insurance	Thomas P. Zacharias
EC1.2	Providing a Science-Practice Interface to Decision Makers through Global Environmental Change and Food Systems (GECAFS) Decision Support System Research	Arvin Mosier, Jim Jones, Steve Sonka, Greg Kiker, John Ingram, Mike Brklacich
EC1.3	Active Fire Observations from MODIS to Support Decision Making	I. Csiszar, C.O. Justice, J. Descloitres, D. Davies, L. Giglio, R. Sohlberg
EC1.4	Assessing Impacts of Changing Land Use, Climate and Atmospheric Chemistry on Forests of the Chesapeake Bay Watershed	Richard Birdsey, Yude Pan, Eric Sprague, John Hom, Kevin McCullough
EC1.5	Designing Wetland Conservation Strategies under Climate Change	Jiayi Li, Elizabeth Marshall, James Shortle, Richard Ready, Carl Hershner
EC1.6	A Tool for Screening Projects for Risks from Climate Change	Ian Noble, Fareeha Iqbal
EC1.7	Ocean Climate Decision Making Systems for Predicting Catch in Pelagic Fisheries	Mitchell A. Roffer
EC1.8	The Implications of Climate Change in the Management of Vulnerable Species – The Case Study of Polar Bears	George M. Durner, Steven C. Amstrup, David C. Douglas, Gennady I. Belchansky, Geoffery York, Ryan Nielson, Trent McDonald
EC1.9	TNC's Adaptation Efforts in Conservation Landscapes: Models for Federal Land Managers?	Earl Saxon, Bill Stanley, Sam Pearsall
EC1.10	Linking Health and Environmental Data in a Public Health Surveillance System	Doug Rickman, Amanda Sue Niskar, Judith Qualters, Dale Quattrochi, Maury Estes, Ashutosh Limaye, William Crosson, Mohammad Al-Hamdan
	Coastal Management: Application of Climate Science (CO) Sub-Theme 1: Climate and Coastal Infrastructure: Applications and Information Needs	
CO1.1	Climate and Coastal Communities: Improving the Decision-Making Process	Eileen L. Shea
CO1.2	Using Paleotempestology in Support of Decision Making Under Uncertainty of Hurricane Climate Variability	Kam-biu Liu
CO1.3	Sea Level Rise: A Trendy Perspective	Len Pietrafesa, Dave Dickey, Lian Xie
CO1.4	Informing Decision Makers of the Potential Impacts of Sea Level Rise on the Coastal Region of New Jersey, USA	Michael D. Beevers, Matthew J.P. Cooper, Michael Oppenheimer
CO1.5	Overview of Information Needed to Adapt to Rising Sea Level	James Titus
CO1.6	Sea Level Rise and Ground Water Sourced Community Water Supplies in Florida	John Furlow, Randall Freed, Susan Herrod-Julius
CO1.7	Context and Climate Change: Lessons from Barrow, Alaska	Ronald D. Brunner, Amanda Lynch, James Maslanik
CO1.8	Climate Change and Coastal Cities: Information for Decision Making	Roberta Balstad, W. Christopher Lenhardt
CO1.9	A Resource Manager's Perspective on Applications and Information Needs	Susan Snow-Cotter
	Coastal Management: Application of Climate Science (CO) Sub-Theme 2: Climate and Coastal Ecosystems: Supporting Adaptive Management	
CO2.1	Understanding the Future of Coastal Wetlands in the Face of Sea-Level Rise: Lessons from Coastal Louisiana	Denise J. Reed
CO2.2	SELVA-MANGRO: An Integrated Landscape and Stand Simulation Model for Predicting Mangrove Forest Growth and Distribution across the Everglades Coastal Margin under Changing Climate	Thomas Doyle, Kenneth Krauss, Jason Sullivan, Andrew From
CO2.3	Using Climate Change to Information to Support Adaptive Coastal Conservation	Lynne Hale
CO2.4	An Information Guide for Strategic Management of Coral Reefs in a Changing Climate	Jordan West, Paul Marshall, Heidi Schuttenberg, Roger Griffis
CO2.5	A Resource Manager's Perspective on Supporting Adaptive Management	Billy Causey

Abstracts for Speakers: Session 4 (continued)

	Abstract Title	Authors
	Air Quality Management: Application of Climate Science (AQ) Sub-Theme 1: Climate Change, Air Quality and Human Health	
AQ1.1	Review of the Health Effects Potentially Associated with Projected Changes in Concentrations of Air Pollutants and Aeroallergens	Kristie Ebi
AQ1.2	Impact of Climate Change on Air Pollution Episodes in the United States	L.J. Mickley, D.J. Jacob, B.D. Field, D. Rind, J.S. Fu, J.H. Seinfeld, D.G. Streets
AQ1.3	Ozone Air Quality Management through Methane Emission Reductions: Global Health Benefits	J. Jason West, Arlene M. Fiore, Larry W. Horowitz, Denise L. Mauzerall
AQ1.4	EPRI Workshop on Interactions of Climate Change and Air Quality: Findings and Recommendations	Daniel J. Jacob
	Air Quality Management: Application of Climate Science (AQ) Sub-Theme 2: Linking Climate Change Research to Air Quality Decisions	
AQ2.1	Towards an Integrated Observing System for Air Quality Decision Making	Doreen Neil, R.B. Pierce, James Szykman, Jack Fishman
AQ2.2	Integrating Climate Modeling and Remote Sensing Data to Improve Public Health Decision Support Tools - Part I	Stanley Morain, Amelia Budge, Karl Benedict, William Hudspeth, Thomas Budge, Gary Sanchez, William Sprigg
AQ2.3	Supporting Long-Term Regional Air Quality Management in Response to Global Change	Dan Loughlin, Gary Kleiman, Bryan Hubbell, Darryl Weatherhead
AQ2.4	Application of an Integrated Modeling System for Climate and Air Quality Change Studies at Regional to Local Scales	Xin-Zhong Liang, Ho-Chun Huang, Allen Williams, Michael Caughey, Kenneth Kunkel, Donald Wuebbles
AQ2.5	Development and Evaluation of a Methodology for Determining Air Pollution Emissions Relative to Geophysical and Societal Change	Allen Williams, Geoffery Hewings, Zhining Tao, Kieran Donaghy, Donald Wuebbles
	Energy Systems: Application of Climate Science (EN) Brief Overview	
EN0.1	Brief Overview: CCSP Activities Informing Decision Making	Jerry Elwood
EN0.2	Brief Overview: CCTP Activities Informing Decision Making	David Conover
	Energy Systems: Application of Climate Science (EN) Sub-Theme 1: Science Informing Operational and Short-Term Decision Making	
EN1.1	Climate Science Applications to Support Short-Term, Operational Decision Making for a Utility and for Financial Commodities Trading	David D'Arcangelo
EN1.2	NASA Satellite Measurements and Modeling Contributions to Decision Support in the Energy Sector	Richard S. Eckman, Paul W. Stackhouse, Mayra N. Montrose
EN1.3	Climate Forecasts for Improving Management of Energy and Hydropower Resources in the Western U.S.	Anthony Westerling, Eric Alfaro, Mary Altalo, Tim Barnett, Todd Davis, Phil Graham, Alan Hamlet, Dennis Lettenmaier, David Pierce, Anne Steinemann, Nathalie Voisin
EN1.4	Translating Research Results into Resource Plans at the State Level	Franco Guido
	Energy Systems: Application of Climate Science (EN) Sub-Theme 2: Long-Term Planning and Investment, Including Carbon Management and Integrated Assessment	
EN2.1	Science Needs to Inform Long-Term Decision Making in the Energy Sector	TBD
EN2.2	Improving Climate Information for Hydroelectric Dam Relicensing	Kirstin Dow, Greg Carbone, Kirsten Lackstrom
EN2.3	Planning Bio-Energy Options: Climate Feedbacks and Information Needs	Robin L. Graham
EN2.4	Science for Carbon Management: Making Effective Connections Between Users and Producers of Information	L. Dilling, D. Fairman, R. Pielke, A. King
EN2.5	The Future of Integrated Assessment Modeling as a Decision Support Tool for Energy and Climate	Gerald Stokes
EN2.6	Tools for Interactive Decision Making under Uncertainty on Energy and Climate Change	Jurgen Scheffran

List of Poster Abstract Titles and Authors

Abstracts for Posters: Evening Session – 14 November 2005

	Abstract Title	Authors
	Decision Support: Processes & Products (P-DS) Sub-Theme 1: Scientific Assessments	
P-DS1.1	CCSP Poster on Synthesis and Assessment Product 1.2: Past Climate Variability and Change in the Arctic and at High Latitudes	Thomas R. Armstrong, Joan Fitzpatrick
P-DS1.2	Climate Projections for Research and Assessment Based on Emissions Scenarios Developed through the CCTP - Synthesis and Assessment Product 3.2	Hiram Levy
P-DS1.3	CCSP Poster on Synthesis and Assessment Product 3.4: Risks of Abrupt Changes in Global Climate	Thomas R. Armstrong
P-DS1.4	National Academies Reports on Radiative Forcings and Climate Change Feedbacks	Ian Kraucunas, Chris Elfring, Amanda Staudt, Daniel Jacob, Dennis Hartmann
P-DS1.5	CCSP Synthesis and Assessment Product 4.2: State-of-knowledge of Thresholds of Change that Could Lead to Discontinuities (Sudden Changes) in Ecosystems and Climate-Sensitive Resources	Jack Waide, William Hohenstein, Bryce Stokes, Jeff Amthor, Susan Herrod-Julius, Kenric Osgood, Henry Gholz
P-DS1.6	CCSP Poster on Synthesis and Assessment Product 4.3: The Effects of Climate Change on Agriculture, Biodiversity, Land, & Water Resources	William Hohenstein, Bryce Stokes, Jack Waide, Jeff Amthor, Susan Herrod-Julius, Woody Turner, Paula Bontempi, Ned Cyr, Tom O'Connor, Kenric Osgood, Henry Gholz, Phil Taylor
P-DS1.7	CCSP Synthesis and Assessment Product 4.4: Preliminary Review of Adaptation Options for Climate Sensitive Ecosystems and Resources	Susan Julius, Bryce Stokes, Bill Hohenstein, Jack Waide, Woody Turner, Ed Sheffner, Kenric Osgood, Ned Cyr
P-DS1.8	CCSP Synthesis and Assessment Product 4.5: Analyses of Effects of Global Change on Energy Production and Consumption	Tom Wilbanks, Jerry Elwood
P-DS1.9	CCSP Synthesis and Assessment Product 4.6: Analyses of the Effects of Global Change on Human Health and Welfare and Human Systems	Janet L. Gamble, Anne Grambsch, John Houghton, Lawrence Friedl, Caitlin Simpson
P-DS1.10	CCSP Synthesis and Assessment Product 5.2: Best Practice Approaches for Characterizing, Communicating and Incorporating Scientific Uncertainty in Climate Decision Making	M. Granger Morgan
P-DS1.11	The National Academies: Informing National Decisions on Climate and Global Change	Gregory Symmes
P-DS1.12	Lessons Learned from Decision Support Processes in Place-based Settings	Janet Gamble, Frances Sussman, Susan Julius, Randy Freed, John Furlow, Melinda Harris, Jordan West
P-DS1.13	Meeting Societal Needs: Regional Integrated Assessments in Support of Decision Making	Amy Luers, Peter Frumhoff, Susanne Moser
P-DS1.14	A Synthesis and Outreach Program on Climate Variability and Change Research in the Northeastern U.S. and Eastern Canada	Lindsey Rustad, Roger Cox, Marc Deblois, Jeffrey Dukes, Andrew Richardson ,Barry Rock, Mark Watson , Norman Willard
	Decision Support: Processes & Products (P-DS) Sub-Theme 2: Estimation & Communication of Uncertainty	
P-DS2.1	Sources, Characterization, and Communication of Uncertainty in Climate Impacts	Bryan Pijanowski, Marianne Huebner, Brent Lofgren
P-DS2.2	Risk Modeling Using Multiple Probability Distributions for the Climate Sensitivity	Paul Baer, Michael Mastrandrea, Malte Meinshausen
P-DS2.3	Simple Climate-Economy Models: Transparent Tools for Policy Making or Opaque Screen Hiding Methodological Arbitrariness?	Hans-Martin Füssel
	Decision Support: Processes & Products (P-DS) Sub-Theme 3: Interface Between Users & Information	
P-DS3.1	Ensuring Climate Services for the Nation	Roger Pulwarty, Kelly Redmond, Fiona Horsfall, Phil Pasteris, Nolan Doesken, Harvey Hill
P-DS3.2	SPARC: Science Policy Assessment and Research on Climate	Roger Pielke Jr.
P-DS3.3	The Multiple Audiences Problem in Constructing Effective Syntheses of Scientific Information for Purposes of Influencing Public Policy	William F. Eadie, Kerk F. Kee
P-DS3.4	An Analysis of Some Problems in the Transmission and Use of Climate Research by Public Policy Decision Makers and Some Suggestions for Improving the Process Using Currently Available Tools	Myron Ebell, Christopher Horner, Marlo Lewis, Iain Murray
P-DS3.5	Development and Gap Analysis of Climate Change Educational Resources Collection for K-12	Mark S. McCaffrey, Frank Niepold
P-DS3.6	Documenting Glacier Change and Landscape Evolution: An Alaskan Example of Providing Scientific Information to Support Decision Making and Outreach and Education	Bruce Molnia
	Decision Support: Processes & Products (P-DS) Sub-Theme 4: International	
P-DS4.1	Robust Adaptation Decisions amid Climate Change Uncertainties	Suraje Dessai, Anglia, Mike Hulme
P-DS4.2	Decision Systems Research and Tool Development at the IRI	Neil Ward, James Hansen, Sankar Arumugam, Daniel Osgood, Lareef Zubair, Casey Brown, Ashok Mishra
P-DS4.3	Applying Climate Variability/Change Information for Early Warning and Response Decision-Making: Lessons Learned from the Conflict Early Warning and Response Mechanism (CEWARN)	Patrick Meier
P-DS4.4	Climate Change Science for Development	Keya Chatterjee, Jon Padgham

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	Abstract Title	Authors
	Food Production (P-FP) Sub-Theme 1: Remote Sensing Applications	
P-FP1.1	The Multiple Roles of Satellite Data in Livelihood Based Famine Early Warning for Decision Makers	Molly Brown, Christopher Funk, Tanya Boudreau, Compton Tucker
P-FP1.2	Global Agricultural Monitoring: Science Information to Inform Decision Making	Chris Justice, Brad Dorn, Matthew Hansen, Jim Tucker, Assaf Anyamba, Mark Sullivan, Inbal Reshef
P-FP1.3	An Agricultural Information System Based on Satellite Remote Sensing Data for Decision Making	Bill Teng
P-FP1.4	Integrating Remote Sensing and other Products into the Decision Support Systems of the United Nations World Food Programme	Zhong Liu, Lenard Milich, William Teng, Long Chiu, Steven Kempler, Hualan Rui
P-FP1.5	Climate Constraints, Water Limitation and Global Food Security	Felix Kogan
	Food Production (P-FP) Sub-Theme 2: Regional International Applications	
P-FP2.1	A Prototype, Scenario-Based, Decision Support System for Integrating Food Security and Ecosystem Management in Jamaica	Greg Kiker, Mindy Kiker, Arvin Mosier, Jim Jones, Igor Linkov
P-FP2.2	Climate Change Impact on Food Security and Policy Adaptations: A Synthesis from Selected African Countries	Tanveer A. Butt, Bruce A. McCarl
	Food Production (P-FP) Sub-Theme 3: Impact Modeling	
P-FP3.1	Linking Seasonal Climate Forecasts with Crop Simulation to Optimize Maize Management	Ashok Mishra, James Hansen, K.P.C. Rao, Durton Nanja, Elijah Mukhala
P-FP3.2	Effects of Climate Variability on Irrigation Water Use in the Southeastern United States	J.O. Paz, G. Hoogenboom, A. Garcia y Garcia, L.C. Guerra1, J.G. Bellow, C. W. Fraisse, J.W. Jones
P-FP3.3	Impact of Climate Information in Reducing Farm Risk by Selecting Crop Insurance Programs	Victor Cabrera, Clyde Fraisse, David Letson, Guillermo Podesta, James Novak
P-FP3.4	A Climate-based Tool for Agricultural Nitrogen Management Decisions	Arthur T. DeGaetano, Laura Joseph, Jeffrey J. Melkonian
	Food Production (P-FP) Sub-Theme 4: Decision Support Projects & Programs	
P-FP4.1	Applications of Climate Information to Agriculture in the Southeast USA: A Perspective from Agricultural Extension Services	Joan Dusky
P-FP4.2	The Pileus Project: Climate Science in Support of Decision Making	J. Roy Black, Julie A. Winkler, Jeffrey A. Andresen, Jeanne Bisanz, Costanza Zavalloni
P-FP4.3	Farmer Climate Risk Management: Insights into Climate Change Adaptation Capacity	Jennifer Phillips, David Krantz, Brad Lyon
	Ecosystems (P-EC) Sub-Theme 1: Observations & Applications	
P-EC1.1	Influence of Climate Variability on Regional Vegetation and Water Cycle over the East Coast of the United States	Donglian Sun, Menas Kafatos, Ruixin Yang
P-EC1.2	Satellite-derived MODIS Vegetation Attributes: Indicators of Climatic Effects on Biodiversity and Productivity Across the U.S.A.?	J.M. Nightingale, N.C. Coops, R.H. Waring, W. Fan
P-EC1.3	Altered Climate and Ecosystem Response: The Long-Term Ecological Research Program (LTER)	Jim Gosz, Mark Williams, Deb Peters, Alan Knapp
P-EC1.4	Climate LINKages of UPland-Lowland Environments (LINKUP)	Henry Diaz
	Ecosystems (P-EC) Sub-Theme 2: Wildfire	
P-EC2.1	Addressing the Impact of Climate Change on Wildland Fires	Margaret R. McCalla, Mary M. Cairns, Mark J. Welshinger
P-EC2.2	Keepers of the Flame: The Role and Use of Climate in National and Regional Fire Policy	Timothy Brown, Roger Pulwarty
P-EC2.3	Using Fire and Climate History for Assessing Current and Future Fire Hazards	Thomas Swetnam, Michael Crimmins, Barbara Morehouse
P-EC2.4	Using Satellite-Based Fire Products to Enhance the National Emissions Inventory	Amber Soja, Jay Al-Saadi, Brad Pierce, James Szykman, David J. Williams, Tom Pierce, Tom Pace, Joe Kordzi
P-EC2.5	The MODIS Rapid Response Project: A New Suite of Remote Sensing Products in Support of Decision Making	Jacques Descloitres, Jeff Schmaltz, Jackie Kendall, Louis Giglio, Chris Justice, Holli Riebeek
P-EC2.6	Statistical Modeling of Western Wildfire Season Severity for Decision Support	Anthony Westerling, Tim Barnett, Daniel Cayan, Michael Dettinger, Alexander Gershunov, Hugo Hidalgo
	Ecosystems (P-EC) Sub-Theme 3: Land & Wildlife Management	
P-EC3.1	Decision Support Tools for Adaptive Forest Management	William T. Sommers
P-EC3.2	Interim Wildlife Management and Global Climate	Douglas Inkley
P-EC3.3	Redesigning Conservation for Climate Change	Lara Hansen, Eric Mielbrecht, Jennifer Biringer, Jennifer Hoffman

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P-EC4.1	A Modeling Study of Climate-Ecosystem Interaction Over North America	Ming Chen, Huiting Mao, Robert Talbot
P-EC4.2	Transient Dynamics of Vegetation Response to Past and Future Major Climatic Changes in the Southwestern United States	Kenneth Cole, Kirsten Larsen, Phillip Duffy, Samantha Arundel
P-EC4.3	Potential Widespread Forest Dieback in North America: What is the Price of Uncertainty	Ronald P. Neilson, James M. Lenihan, Dominique Bachelet, Raymond J. Drapek, F.I. Woodward, M. Lomas, The VINCERA investigators
P-EC4.4	Vulnerability of Northern Prairie Wetlands to Climate Change: Implications for Waterfowl	Glenn Guntenspergen, Carter Johnson, David Naugle
P-EC4.5	Eastern Deciduous Forest Responses to Climatic Change Drivers: An Upland-Oak Forest Case Study	Paul J. Hanson, Stan D. Wullschleger, Jeffery S. Amthor
P-EC4.6	Rising Atmospheric Carbon Dioxide as a Factor in the Success of Invasive Weeds	L.H. Ziska
	Carbon (P-CA) Sub-Theme 1: Sequestration in Ecosystems	
P-CA1.1	Using Ecosystem Models to Inventory and Mitigate Environmental Impacts of Agriculture	Stephen Del Grosso, Steve Ogle, William Paron, Keith Paustian, Ronald Follett
P-CA1.2	Renewable Energy as an Emission Control Alternative: Agricultural and Forestry Sector Roles	B.A. McCarl, J.C. Cornforth, R. Ismailova, W. You, M. El Halwagi, T. Mohan, X. Qin
P-CA1.3	Estimating U.S. Forest-Agriculture Climate Change Mitigation Opportunities at the National and Regional Scales using Economic, Policy, and Co-Benefits Criteria	Brian Murray, Bruce McCarl, Kenneth Andrasko, Benjamin DeAngelo, Brent Sohngen
P-CA1.4	A Modeling Framework to Relate Agricultural Practice, Land-Use Change, Energy Use, and Greenhouse Gas Emissions on Agricultural Lands in the USA: Integrating Carbon Accounting with Survey Data, Remote Sensing, and Economic Modeling	Tristram West, Gregg Marland, Craig Brandt, Daniel De La Torre Ugarte, James Larson, Budhendra Bhaduri, Sally Mueller, Aarthy Sabesan, Chad Hellwinkle, Brad Wilson
P-CA1.5	Determining the Long-Term Impact of Bioenergy Crops on the Global Warming Potential of Energy Use	Paul R. Adler, Steven J. Del Grosso, William J. Parton, William E. Easterling
P-CA1.6	COLE: Carbon OnLine Estimation Web Tool for Continental U.S. Forest Ecosystems	Linda S. Heath, Paul C. Van Deusen, Michael P. Spinney, Jeffrey H. Gove, James E. Smith
P-CA1.7	Spatial Biological and Industrial Carbon Budgets for Northern WI	D.E. Ahl, M.K. White, S.T. Gower, B. Bond-Lamberty, D. Helmers, S. Peckham
P-CA1.8	Carbon Sequestration Potential in New Mexico Rangelands	Jay Angerer, Joel Brown, Robert Blaisdell, Jerry Stuth
P-CA1.9	Summer and Winter Precipitation: Effects on Carbon Sequestration and Timber Production under Current and Future Atmospheric CO_2	Ram Oren, Heather McCarthy, Sari Palmroth, Kurt Johnsen
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P-CA2.1	Nutrient Management to Enhance Carbon Sequestration in Piedmont Forests of the Southeastern U.S.	Peter Kapeluck, Wayne Carroll, David Van Lear, Elena Mikhailova, Christopher Post, Mark Schlautman, Wilfred Post, Chuck Garten, Phillip Jardine
P-CA2.2	Unaccounted Soil Carbon Stocks	Elena Mikhailova, Christopher Post, Kim Magrini-Bair
P-CA2.3	Estimating Soil C Changes for the US 1605B Program "Voluntary Reporting of Greenhouse Gas Mitigation"	Keith Paustian, John Brenner, Stephen Ogle, Mark Easter, Kendrick Killian, Jill Schuler, Steve Williams
P-CA2.4	Practical Applications of Uncertainty Analysis for National Greenhouse Gas Inventories	Michael Gillenwater, Fran Sussman, Jonathan Cohen
P-CA2.5	Spatiotemporally Explicit Maps of Anthropogenic CO_2 Emissions for NACP	Marc Fischer, Kevin Gurney, Scott Denning, Steve Knox, Gregg Marland, Dennis Ojima, Lynn Price, Jayant Sathaye
P-CA2.6	Time Series Calibrated Carbon Emissions and Atmospheric Response	Clifford E. Singer
P-CA2.7	Carbon America: Providing Regional Carbon Emissions and Uptake Information for Carbon Management	David Hofmann, Pieter Tans
P-CA2.8	Monitoring CO_2 from Space: The NASA Orbiting Carbon Observatory Mission	David Crisp, The OCO Team
P-CA2.9	Methane Emissions from Natural Wetlands in the United States: Satellite-Derived Estimation Based on Ecosystem Carbon Cycling	Christopher Potter, Steven Klooster, Seth Hiatt, Matthew Fladeland, Peggy Gross
P-CA2.10	Carbon Budgets for Ecosystems of the Continental United States	Christopher Potter, Steven Klooster, Vanessa Genovese, Matthew Fladeland
P-CA2.11	The U.S.-China Carbon Consortium (USCCC) and Its Contribution to Global Change Studies	Jiquan Chen
P-CA2.12	Urban and Regional Carbon Management: Comparative Framework of the Global Carbon Project	Penelope Canan
P-CA2.13	A Bayesian Synthesis Inversion of Carbon Cycle Observations: How Do Observations Reduce Uncertainties About Future Sinks?	Daniel Ricciuto, Klaus Keller, Kenneth Davis
P-CA2.14	Methodology and Cost of Evaluating Soil Carbon Stocks in a 2-m Soil Profile	Christopher Post, Elena Mikhailova, Kim Magrini-Bair
P-CA2.15	Carbon-Climate System Feedbacks to Natural and Anthropogenic Climate Change	S.C. Doney, I. Fung, K. Lindsay, J. John

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P-CO1.2	Impact of Sea-Level Rise on the Mid- and Upper-Atlantic Coast	Shuang-Ye Wu, Raymond Najjar, John Siewert
P-CO1.3	An End-User Defined Coastal Climatology Product for Recreation and Tourism in Southeastern North Carolina	Douglas W. Gamble, Lynn Leonard
P-CO1.4	Global Climate Change Impacts on Coastal Infrastructure Services	Rae Zimmerman
P-CO1.5	Which Uncertainties Matter for Decision-Making? Development of an Integrative Decision-Centered Screening Tool with an Application to Coastal Management in California	Susanne Moser
P-CO1.6	The Consortium for Atlantic Regional Assessment: Bringing Climate and Land Use Change Information to Local and Regional Decision Makers	Brandi Nagle, James Shortle, Rachael Dempsey, Jennison Kipp
	Coastal (P-CO) Sub-Theme 2: Wetlands	
P-CO2.1	Choice Modeling Tools to Inform Climate Change Decision-Making: A Case Study on Public Preferences for Coastal Wetland Restoration	Frank Lupi, Michael Kaplowitz, John Hoehn
P-CO2.2	Sea Level Rise and Potential Change in Coastal Bird Habitat in New Jersey, USA	Michael D. Beevers
P-CO2.3	Prediction of Ecological Effects of Sea Level Rise in North Carolina through Coupled Hydrodynamic, Digital Elevation, & Habitat Models	C. Auer, J. Feyen, K. Hess, E. Spargo, S. White, J. Sellars, S. Gill
P-CO2.4	Predicting the Persistence of Coastal Wetlands to Global Change Effects	Glenn Guntenspergen, Donald Cahoon
P-CO2.5	Studies of Climate-Driven Changes in Lake Levels Assist in Decision Making in the Great Lakes Region	Douglas A. Wilcox, Todd A. Thompson, Steve J. Baedke
	Coastal (P-CO) Sub-Theme 3: Reefs and Fisheries	
P-CO3.1	Decision Support Tools for Coral Reef Management under Changing Climates	John W. McManus, Felimon C. Gayanilo, Amit L. Hazra, Marilyn E. Brandt, Alette T. Yñ'96iguez, Wade T. Cooper, Johnathan Kool, Catherine A. Bliss
P-CO3.2	Coupling Remote Sensing and In-Situ Data to Derive a Calcification Index for Coral Reef Ecosystems	Dwight K. Gledhill
P-CO3.3	Climate and Ecosystem Research to Advance Fisheries Management	Kenric E. Osgood
	Water & Energy (P-WE) Sub-Theme 1: Decision Support Applications: Practice & Theory	
P-WE1.1	Pacific ENSO Applications Center (PEAC): The First Decade	Eileen Shea
P-WE1.2	Climate Change - A Looming Challenge for California: Applying State and Federal Science to Inform Decision Makers	Daniel Cayan, Michael Dettinger, Kelly Redmond, Anthony Westerling, Guido Franco, Frank Gehrke, Mary Tyree, Noah Knowles, Hugo Hidalgo, Alexander Gershunov, Laura Edwards, David Pierce, Peter Bromirski
P-WE1.3	The Western Water Assessment: Integrated Sciences for Decision Support	Bradley Udall, Roger Pulwarty, Martyn Clark, Doug Kenney, Chris Goemans, Randy Dole, Susan Avery
P-WE1.4	Effecting Systemic Change in Climate Information Delivery and Decision Support	Holly Hartmann
P-WE1.5	Barriers to Weather and Climate Forecast Use by Community Water System Managers	Brent Yarnal, Robert O'Connor, Kirstin Dow, Christine L. Jocoy, Greg Carbone
P-WE1.6	Integrating Climate Information into Decision Making for Support of Water Management: A Protocol	Qi Hu, Roger Bruning, Lisa PytlikZillig, Gary Lynne, Kenneth Hubbard
P-WE1.7	Infrastructure to Document Local Hydroclimatic Vulnerabilities to Climate Variation and Change	John Harrington, Brent Yarnal, Andrew Comrie, Colin Polsky
P-WE1.8	Climate Information Needs for Decision Makers: Special Reference to Water	Leonard Berry, Lakhdar Boukerrou
P-WE1.9	Adapting New York City's Water Supply and Wastewater Treatment Systems to Climate Change	David C. Major, Cynthia Rosenzweig, Kate Demong, Christina Stanton
P-WE1.10	The Water Cycle Solutions Network	Paul Houser, Debbie Belvedere, Bisher Imam, Rick Lawford, Fritz Policielli, Robert Schiffer, C. Adam Schlosser, Hoshin Gupta, David Toll, Claire Welty, Charles Vorosmarty, David Matthews
P-WE1.11	Demonstrating Land Information System Decision Support Solutions	Paul Houser, Kristi Aresnault, Christa Peters-Lidard, David Toll
P-WE1.12	Drought Monitoring in Oklahoma: A Collaborative Endeavor	Mark A. Shafer, S. Arndt
P-WE1.13	Applying Planetary Water and Energy Cycle Science and Observations to Regional and Local Decision Making in the Water Sector	Rick Lawford
P-WE1.14	Development and Presentation of Climate-Based Streamflow Forecast Tools for Water Resource Manages in the Puget Sound Region	Richard Palmer, Matthew Wiley
P-WE1.15	Water Supply Forecasting for the Western U.S.	Phillip Pasteris, Tom Pagano
P-WE1.16	Hydroclimatic Reconstructions for Decision Support in the Colorado River Basin	Connie Woodhouse, Robert S. Webb, Gregg Garfin, Brad Udall
P-WE1.17	California's Coupled Water and Energy Response to Climate Change	Norman Miller, Larry Dale, Tariq Kadir
P-WE1.18	The Role of Climate Change in Thermoelectric Cooling Water Systems	B.T. Smith, A.W. King, M. . Branstetter, C C. Coutant, P.J. Mulholland, M.J. Sale
P-WE1.19	Climate-Driven Increases in Extreme Heat and Energy Demand in California	Norman L. Miller, Katharine Hayhoe, Jiming Jin
P-WE1.20	Climate Change Impacts on California's Energy Security Planning	Steven Fernandez, James Bossert, Loren Toole, Sam Flaim
P-WE1.21	Using Climate Models Output in Adapting to Climate Change	Joel B. Smith, Tom M. L. Wigley

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P-WE2.2	Global Land Data Assimilation System (GLDAS) Products Available to Support Hydroclimatology and Decision Making	Matthew Rodell
P-WE2.3	Drought Monitoring and Applications of NASA's Hydrosphere States Mission	Christa Peters-Lidard, Peggy O'Neill, Dara Entekhabi, Eni Njoku, Paul Houser, Randy Koster
P-WE2.4	The Hydrologic Ensemble Prediction Experiment (HEPEX) Project	John Schaake
P-WE2.5	Climate Services for Water Resources Decision Support: An Overview of the State of the Practice and Some Implications Associated with Global Warming	Alan Hamlet, Edward Miles, Edward Sarachik
P-WE2.6	Assessing the Implications of Climate Variability and Change for Western Water Resources	Andrew W. Wood, Dennis P. Lettenmaier, Tim P. Barnett
P-WE2.7	Impacts of a Warming Climate on Water Availability in Snow-Dominated Regions	Jennifer Adam, Tim Barnett, Dennis Lettenmaier
P-WE2.8	Effects of Water Resources: Monitoring Snowmelt Runoff and Sea Level for Climate Change	Maury Roos
P-WE2.9	Regional Impacts of Climate Change, Landuse Change, and Human Population Dynamics on Water Availability and Demand across the Southeastern U.S.	Ge Sun, Steven G. McNulty, Erika Cohen, Jennifer Moore Myers, David Wear
P-WE2.10	Decision Support System for the Effects of Climate Change on Water Supply in San Juan River Basin	Carl W. Chen, Laura H.Z. Weintraub, Limin Chen, Joel W. Herr, Paul M. Rich, R.A. Goldstein
P-WE2.11	An Assessment of the Effectiveness of Riparian Buffers for Reducing Sediment Loading to Streams Under Alternative Climate Change Scenarios	T. Johnson, M. Huang, J. Furlow, C. Rogers, R. Freed, D. Pape
P-WE2.12	Assessing the Impact of Climate Change on the Hydrology and Water Quality of the Upper Mississippi River	Eugene Takle, Manoj Jha, Christopher Anderson, Phil Gassman
	Air Quality and Health (P-AQ)	
P-AQ1.1	Integrating Climate Modeling and Remote Sensing Data to Improve Public Health Decision Support Tools: Model Results - Part II	Dazhong Yin, Brian Barbaris, William A. Sprigg
P-AQ1.2	Possibilities and Challenges in Using Satellite Data for PM2.5 Forecasts	Mian Chin, Hongbin Yu, Allen Chu
P-AQ1.3	Satellite-Derived High Resolution Land Use/Land Cover Data to Improve Urban Air Quality Model Forecasts and Decision Making	Dale Quattrochi, William Crosson, Maury Estes, Maudood Khan
P-AQ1.4	Global Atmospheric Pollution Studies Using Space-Based Observations Alongside Global Modeling and Data Assimilation Tools Developed in NASA's Global Modeling and Assimilation Office	Steven Pawson, Ivanka Stajner, Julio Bacmeister, Andrew Tangborn
P-AQ1.5	Effects of Urbanization on Meteorology, Biogenic Emissions, and Air Quality in the Houston-Galveston Area (HGA) in Texas, USA	Daewon Byun, Soontae Kim, Fang-Yi Cheng
P-AQ1.6	Accounting for Uncertainty in Future Climate Change and Evaluating Its Effects on Regional Air Quality	Kasemsan Manomaiphiboon, Armistead G. Russell, Chien Wang, Cassandra B. Roth, Lai-Yung Leung, Jung-Hun Woo, Praveen Amar, Shan He
P-AQ1.7	Examining the Impact of Climate Change and Variability on Regional Air Quality over the United States	Ellen Cooter, Robert Gilliam, Alice Gilliland, William Benjey, Jenise Swall, Chris Nolte
P-AQ1.8	Assessing Potential Health Impacts of Ozone and PM2.5 Under a Changing Climate	Patrick Kinney, Michelle Bell, Christian Hogrefe, Cynthia Rosenzweig, Kim Knowlton
P-AQ1.9	Criteria for Evaluation of Heat Event Early Warning Systems	Kristie L. Ebi, R. Sari Kovats
P-AQ1.10	Integration of NASA Data into ArboNET/Plague Surveillance System	Jorge E. Pinzon, Compton J. Tucker, Kenneth L.Gage, Russell E.Enscore
	General Climate Science (P-GC) Sub-Theme 1: Earth System Analysis & Products	
P-GC1.1	Warming of the World Ocean, 1955-2003	Syd Levitus
P-GC1.2	Assessing Risk of a Collapse of the Atlantic Thermohaline Circulation	Michael E. Schlesinger
P-GC1.3	Estimating the Probability of Future Climate Shifts	David Enfield
P-GC1.4	More on Hockey Sticks: The Case of Jones et al. [1998]	Stephen McIntyre
P-GC1.5	Assessment of U.S. Climate Variations Using the U.S. Climate Extremes Index and the U.S. Greenhouse Climate Response Index	David Karoly, Aaron Ruppert, David Easterling, Jay Lawrimore
P-GC1.6	Relative Sea Level Trends from Tide Stations: How Are They Determined and What Do They Tell Us?	Chris Zervas, Stephen Gill, Allison Stolz
P-GC1.7	A Maturity Model for Satellite-Derived Climate Data Records	Bruce R. Barkstrom, John J. Bates
P-GC1.8	The Contribution of Earth Science Remote Sensing Data to Natural Resources Policymaking	Molly Macauley, Fred Vukovich
P-GC1.9	Accessing NOAA Daily Temperature and Precipitation Extremes Based on Combined/Threaded Station Records	Timothy W. Owen, Keith Eggleston, Art DeGaetano, Robert Leffler
P-GC1.10	NOAA Climate Prediction Center Products for Decision Making	James Laver
P-GC1.11	Aerosol Direct Radiative Effects Over the Northwest Atlantic, Northwest Pacific, and North Indian Oceans: Estimates Based on In-Situ Chemical and Optical Measurements and Chemical Transport Modeling and Their Relation to Decision-Support Information	A. Ravishankara, Timothy Bates, Theodore Anderson, Greogory Carmichael, Anthony Clarke, Caryn Erlick, Lawrence Horowitz, Patricia Quinn, Stephen Schwartz, H. Maring
P-GC1.12	Response of a Coupled Chemistry-Climate Model to Changes in Aerosol Emissions	Jean-Francois Lamarque, Jeff Kiehl, Peter Hess, Louisa Emmons, Paul Ginoux, Chao Luo, XueXi Tie
P-GC1.13	Aviation and the Global Atmosphere: The State of the Science and Future Research Needs	Lourdes Maurice, Curtis Holsclaw, Maryalice Locke, Ian Waitz, Stephen Lukachko, Rick Miake-Lye

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P-GC2.1	Simulations of Committed Climate Change and Sea-Level Rise through 2400 AD	William Collins, Gerald Meehl, Tom Wigley, Haiyan Teng
P-GC2.2	Model Evaluation and Projections of Climate for the Middle and Upper Atlantic Region of the United States	Raymond Najjar, Steve Graham, Steve Crawford, Steve Greybush
P-GC2.3	Development of Regional Probabilities of Climatic Change for Decision Making	Linda Mearns, Claudia Tebaldi, David Yates, Kathleen Miller
P-GC2.4	Evaluation of Regional Climate Simulations for Water Resources and Air Quality Assessment	L. Ruby Leung, Yun Qian, William Gustafson
P-GC2.5	The North American Regional Climate Change Assessment Program (NARCCAP): Multiple AOGCM and RCM Climate Scenario Projections for North America	William Gutowski, Linda Mearns, Raymond Arritt, Sebastien Biner, George Boer, Daniel Caya, Phil Duffy, Michel Giguere, Filippo Giorgi, Isaac Held, Richard Jones, Rene Laprise, Ruby Leung, Ana Nunes, Jeremy Pal, Yun Qian, John Roads, Lisa Sloan, Eugene Takle
P-GC2.6	Observed and Modeled Climate Variability over the United States Associated With Major Teleconnection Patterns	Katharine Hayhoe, Anne Hertel, Donald Wuebbles
P-GC2.7	Providing Climate Information Across a Continuum of Time Scales	Arthur M. Greene, Lisa Goddard, Walter Baethgen
P-GC2.8	Needed: A National Policy in Regard to Climate Modeling	David Douglass
P-GC2.9	A Closer Look at Sea Surface Temperature (SST) Trends	S. Fred Singer
P-GC2.10	Issues for Use of Climate Models to Inform Policymakers, Assess Impacts, and Develop Adaptive Strategies	Robert Livezey
P-GC2.11	Towards Interoperability of Global Geospatial Data Sets: Discrete Global Grids	Michael Freeston

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WA1.1

Droughts and Floods: Better Predictions thru Attribution

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Fundamental to advancing predictions of extreme climate and weather states is to explain their origins and causes. This talk examines how well we understand the known severe and sustained droughts of the 20th Century, including the Great Plains Dust Bowl era and the ongoing Western U.S. drought. Modeling work is presented that identifies a significant role for the oceans in such prolonged droughts. The diagnosis of such simulations is used to guide recommendations for future Earth System monitoring and modeling requirements in order to successfully predict drought.

Floods as high impact events are typically associated with individual storms, especially hurricanes. Insight from the scientific community has been especially sought in accounting for the unprecedented Atlantic hurricane season that included Katrina and Rita in 2005. No less important than explaining the Western drought has been the public and decision maker's requests to interpret this intense hurricane behavior. The talk summarizes current understanding of the factors influencing hurricane variability.

WA1.2

Climate in Three Dimensions: Integrated Mountain Climate Observations

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In topographically diverse regions such as the western United States, concentrated centers of population along rivers and coasts rely on resources that originate in relatively small, high-altitude areas. Of these resources, water is the most necessary and therefore most prominent. Other important resources such as timber, grazing lands, minerals, and recreational enjoyment are strongly affected by the availability and use of water. Change is under way in all mountain systems, a result of a complex intersection of factors: demographic, technological, attitudinal, and physical drivers. However, our collective understanding of mountain systems and the way they behave in time is a patchwork quilt. A variety of recent investigations have begun to reveal that fundamental changes have already occurred that are just now being retrospectively identified, quantified, and interpreted. Most of the hydrologically important water in the West originates as precipitation on public lands. Decisions by federal, regional, state, local and private resource managers require accurate and updated information on status, trends and prospects. There are also significant issues of spatial scales of such information. In an assessment of current knowledge and capabilities, physical and ecological scientists working on western United States mountain climate and ecosystems recognized that more communications, improved observations, better integration, and greater attention to the vulnerability of western mountain resources to climate variability and change are needed. The resulting Consortium for Integrated Climate Research in Western Mountains (CIRMOUNT) has sponsored mountain climate conferences in 2004 and 2005, with another planned in 2006. In their manifesto, Mapping New Terrain (expected late summer 2005), consortium and meeting participants identified four urgent challenges facing western North America climate science and policy communities: 1) Mountain regions are vastly under-instrumented to measure climate and long-term changes. 2) Research on western mountain climates and ecosystems is intensive, but scattered and poorly integrated. 3) Societal demands on western mountain ecosystems are exponentially escalating, imposing new stresses on natural resources and rural community capacities. 4) Although mountains are particularly vulnerable to climate-change impacts, projected climate changes have generally been ignored in mountain land-use planning and natural-resource policies to the detriment of their ecosystems and natural resources. Better monitoring is a universally expressed need and must be addressed in order to provide a basis for decision making and decision support throughout the West.

WA1.3

Climate Forecasts and Reservoir Management – Possibilities and Challenges

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A dynamic reservoir water allocation strategy that uses probabilistic inflow forecasts to size annual contracts with pre-specified reliability is presented and the application of the model with two contrasting river basin settings is presented. Traditionally, reservoir rule curves are obtained for the given seasonal/annual demand based on the driest envelope in the entire historical record, thereby adhering to the same rule curve every year for reservoir operation. The utility of climate based reservoir inflow forecasts as an alternative to this apparently conservative strategy is demonstrated. Water managers and practitioners are often risk-averse and are hence reluctant to change their practices; particularly given the perception that use of probabilistic methods induces a new risk. This may be expressed as a concern with forecast skill. The strategy presented here is designed for a participatory water allocation process, where users could express their potential demand for water through statements that cover quantity needed at a particular reliability, the associated willingness to pay, and compensation needed in the event of contract non-performance. Community priorities can also be accommodated, and a system of contracts can be designed that meets multiple needs with specified reliability and priorities, contingent on a probabilistic inflow forecast. These contracts can be used to allocate water each year above and beyond long-term contracts that may have precedence.

By performing retrospective analyses that combines streamflow forecasts with the dynamic water allocation model, we show that considerable reduction in system losses (spill and evaporation) could be achieved resulting in increased reservoir yields by adapting climate forecasts for reservoir management.

Importance of updating the climate forecasts on a monthly basis and its utility in managing hydropower systems are also demonstrated. Results from the analyses also show that streamflow forecasts are more beneficial during above and below normal conditions, which helps in preparing for adverse conditions as well as in setting up contingency measures. Further, analyzing the system performance under different scenarios of storage and demand, we show that the utility of climate information based reservoir inflow forecasts is more pronounced for systems with low storage to demand ratio. As challenges in implementing these scientific developments, we emphasize the importance of institutional setting and the relevant WA policy instruments that will promote climate information based risk management strategies.

WA1.4

Experiences from the Water Resources and Agricultural Sectors during Drought: What Do Users Want? What Do Researchers Want? What is Needed?

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Climatic events and related decisions cross scales of impacts from shorter-term (months) to long-term (decades and longer) and from one state, county or watershed to the next. Decision-making within the management of natural resources occurs in a complex environment with climate as one factor. Our study focuses on the role of climate information in decision making within water resources and agriculture at different scales. The goal is to determine when and how climate plays a role in the water and agricultural sectors and what constitutes usable climatic information through two questions: (i) What is needed to facilitate drought-related decision-making? And, (ii) Where do science, policy and operations meet and how are participatory benchmarks evaluated? We will describe: Who are the "users" of climate-related information?; What constitutes such information and how is it related to management decision calendars and models including thresholds and triggers; Researchers as stakeholders in the process; How are the gaps, such as differing perceptions of risks, addressed? The overarching framework is to elicit data on information needs, quality, acceptability context of use, accessibility and benefit. Lessons are taken from studies carried out in response to the continuing drought in the Western United States. Barriers to incorporation of climate information in such settings have been documented and include technical, cognitive, financial, legal, time and infrastructural constraints. In addition, evolution in the management and institutional context, priorities, principles, and responses may result in mediating the sensitivity of the system to climate variability and change. Approaches to incorporating climate information typically apply simulation and optimization methods to improve the efficiency of operational procedures. Managers frequently perceive such research-based methods as externally generated and not well-matched to knowledge systems and hedging strategies within the management process. In addition, idealized expected values propose misleading estimates of what can be achieved in practice. In this presentation we move beyond a prescriptive emphasis on "format" or "two-way" communications to establishing a dialog about risk and the transactions costs involved in maintaining such a dialog. We show how these criteria may be met through developing active partnerships and through specific tools for communication and collaboration. The goal is to inform the development of risk management tools and processes in the context of science and management innovations under changing environmental and social conditions

WA1.5

Managing Seattle's Water Supply in Step with a Changing Climate

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Seattle Public Utilities (SPU) is responsible for providing a reliable source of drinking water for 1.3 million people, and it is essential that SPU water managers employ water management practices that stay ahead of ongoing changes in the climate of the Pacific Northwest. This presentation describes how particular climatic data products and ongoing in-house research at SPU are playing an increasingly important role in our operations and intermediate to long-range planning, and what improvements in these products would be of significant benefit to our citizens.

WA2.1

A RISA Success Story-The Southeast Climate Consortium

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The Southeast Climate Consortium (SECC) is composed of scientists from the University of Miami, the University of Florida, Florida State University, the University of Georgia, Auburn University, and the University of Alabama, Huntsville. We provide decision support tools for agriculture, water, and fisheries. Visit agclimate.org or coastalclimate.org to test our products. We work closely with extension in the 3 states. We provide climate forecasts of superior quality for our designated sectors.

WA2.2

Users Making Decisions for Water Allocation

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The Bureau of Reclamation, United States Department of the Interior, is currently undertaking the development of shortage criteria for the operation of Lake Mead. These criteria will be used by the Secretary of the Interior to determine when future water supply shortages will be declared and how shortages will be allocated among users of Colorado River water on the mainstem of the Colorado River below Lake Mead. Associated with the development of shortage criteria, Reclamation will also consider options to better coordinate or conjunctively manage Lake Mead and Lake Powell.

The principal modeling tool for analyzing the various shortage criteria options and reservoir conjunctive use options is the Colorado River model operated and maintained by Reclamation. The Reclamation model uses a hydrologic period of record of 1906 to 1995, which may be extended to 2000 or 2002 in the near future.

A fundamental assumption of most water management agencies within the Colorado River Basin is that the future will look like the past. The probability of hydrologic events such as droughts and basic hydrologic data such as river basin mean flows will continue on into the future. Is this a reasonable assumption? Can the process be improved in one of three basic ways?

1) Should the record be expanded backward in time by using reconstructed flows from the analysis of tree rings, which would include more severe droughts?
2) Within the 1906 to 1995 (or 2000) period of record are there certain multidecadal periods such as 1930 to 1960 that may be more representative of the next 20 years than the entire record?
3) Are there models available that might better forecast future hydrologic conditions assuming a continued warming of the atmosphere, e.g., more rain, less snow?

WA2.3

Walking the Talk: RISA Drought Insights for CCSP

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Dan Cayan, CAP - California Applications Program
Keith Ingram, SECC - Southeast Climate Consortium
Philip Mote, PNW-CIG — Pacific Northwest Climate Impacts Group
Eileen Shea, Pacific RISA
Brad Udall, WWA - Western Water Assessment

Recent severe and sustained drought in the United States has awakened decision-makers, including legislators and resource managers, to the impacts of climate variability and change on society and the environment. Drought impacts on water supplies, agriculture, and timber resources vividly illustrate society's vulnerability to climate changes. At the same time, climate sciences are making great strides in producing knowledge that could aid decision-makers in dealing with drought and its many impacts. This presentation, from NOAA's Regional Integrated Sciences and Assessments (RISA) program, gives key findings and illustrations of effective drought-related decision support and stakeholder engagement relevant to the nation's Climate Change Science Program.

As drought evolved and impacts intensified to include large fires, dramatic water supply decreases, and rangeland desiccation, the RISAs noted increased decision maker requests for long-range (seasonal-to-decadal) forecasts, as well as requests for improved information on climate variability, including paleoclimate records of drought and streamflow. Stakeholders requested guidance on climate information and products that could inform their decisions, interpretations of climate forecasts and assessments of their reliability, and background on the caveats to consider when applying drought-related data for decision making. Indeed, many stakeholders now view drought impacts as analogous to possible impacts of climate change or multi-decadal climate variations. To evaluate outcomes, RISAs recommend metrics such as the number and frequency of quality stakeholder interactions, increased demand for climate information or briefings, enhanced complexity of questions, development of further collaborative research, and improved preparedness.

This presentation will draw specific lessons for CCSP from RISA drought investigations, including the following illustrations: (a) establishing a solid foundation of two-way knowledge exchange between climate scientists and state agencies to insert climate science in state drought planning, including development of science-based triggers for mitigation policy and emergency response actions; (b) collaborating with cooperative extension to deliver climate science to rural stakeholders for community drought planning, agricultural decision making, and resource management planning through coordinated outreach, workshops, and decision-support tools; (c) fostering iterative, sustained partnerships with fire managers to develop climate science-based annual forecasts of fire potential that are used for multi-million-dollar resource allocation and prescribed fire decisions, and (d) collaborating with water resources managers to build capacity for the use of seasonal-to-annual forecasts in operations, and paleoclimate information to test assumptions about system reliability.

WA2.4

Robust Adaptation Decisions amid Climate Change Uncertainties

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Mike Hulme, Tyndall Centre for Climate Change Research and University of East Anglia, UK

This presentation deals with the sensitivity of water supply decisions to various uncertainties associated with climate change (e.g., emissions of greenhouse gases, climate sensitivity, global climate models, regional climate models). The setting is in the East of England, in the UK, the driest region in the country where climate change could exacerbate drought-like conditions. UK water companies have to plan for the next 25 years and decide what actions they will take in order to maintain security of supply. They currently take into account climate change by using climate change scenarios produced by the UK Climate Impacts Programme (UKCIP02). Our approach tries to quantify a much larger set of uncertainties than those included in UKCIP02 in the assessment of future climate. We are then able to determine the sensitivity of water adaptation decisions to these uncertainties.

Our role in the decision-support process has not been as purely a “user” or a “producer” of climate information. Our role could be better described as an observer or facilitator in the interface between “user” and “producer.” We have been “producers” of climate information because we have used publicly available climate data to quantify uncertainties in climate change scenarios. This has been done using a combination of a simple climate model and various global and regional climate models. We also interacted with numerous “users” to elicit what adaptation options they were considering.

The presentation will introduce a number of topics such as the type of information decision makers want; use of scientific information (in particular models and their results) to support decision-making; participatory approaches; communicating uncertainty; and methods and metrics to evaluate outcomes. In order to support their decision-making, water companies in the UK would prefer to use probabilistic climate projections rather than scenarios. We have noted that models are important for incorporating climate change into water resources planning. The industry has attempted to follow a simple approach, but because of the complexity introduced by climate change it is particularly important to manage and communicate uncertainties associated with climate change. We have also found that participatory approaches are crucial for the users to trust the information from the producers and for the researchers to elicit adaptation strategies from the users. We evaluated adaptation strategies using criteria based on robustness, i.e. decisions that are insensitive to uncertainties.

WA2.5

Adapting New York City’s Water Supply and Wastewater Treatment Systems to Climate Change

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The New York City Department of Environmental Protection (NYCDEP), the agency responsible for managing New York City’s water supply and wastewater treatment systems, created an agency-wide Climate Change Task Force in 2003. The mission of the Task Force is to ensure that NYCDEP’s strategic and capital planning efficiently take into account the potential effects of climate change—sea level rise, higher temperature, increases in extreme events, and changing precipitation patterns—on NYC’s water systems. In addition to its adaptation activities, the Task Force is developing a GHG management program, using GHG inventory software to support mitigation efforts.

The NYCDEP Task Force, in partnership with Columbia University’s Center for Climate Systems Research (CCSR), is evaluating climate change forecasts, impacts, indicators, and adaptation and mitigation strategies to support agency decision making. A comprehensive framework for analyzing climate change has been created, including a 7-step Adaptation Assessment procedure. Potential climate change adaptations are divided into management, infrastructure, and policy categories, and are assessed by their relevance in terms of climate change time-frame (immediate, interim, and long-term), the capital cycle, and costs and other impacts. A wide range of potential adaptations has been examined, including integrated operations with other systems, storm surge barriers for wastewater treatment plants, and new design criteria for infrastructure that reflect non-stationary hydrologic processes. Climate change indicators have been identified to help guide the timing of adaptations.

Task Force activities also include the development of downscaled climate change scenarios, the coordination of scientific projects to yield maximum benefit from research and development, and internal and external outreach through climate change workshops. For the NYC region, downscaled climate change scenarios are being simulated using the MM5 regional climate model. Mechanisms for updating these scenarios over time are being developed, using evolving climate information on trends and extremes provided by university scientists. As an example of science coordination, Columbia University is coordinating a multi-institution project that integrates scenarios of climate change and sea level rise, hurricane and nor’easter storm-surge modeling and a digital elevation program to estimate flooding risks to coastal infrastructure. NYCDEP is also a member of the European Union CLIME project, helping to develop integrated regional climate and water quality models to study climate change issues in its watersheds. To support its ongoing programs, the Task Force meets monthly; it also engages NYCDEP personnel through climate change science and planning workshops.

EC1.1

The Role of Climate Science in U.S. Crop Insurance

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This presentation will address the role of climate science in U.S. crop insurance primarily from the perspective of private crop insurance carriers. The presentation will begin with a brief description of the U.S. crop insurance market, providing the distinction between federally supported crop insurance and traditional crop-hail insurance both provided by private carriers. The presentation will then focus on the types of underwriting and actuarial decisions routinely faced by the industry. Perceived information and research deficiencies in the current system will be discussed. The presentation will conclude with an assessment of the economic utility of climate science on the future of the industry.

EC1.2

Providing a Science-Practice Interface to Decision Makers through Global Environmental Change and Food Systems (GECAFS) Decision Support System Research

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A relationship exists between current socioeconomic and environmental conditions and food security, and highlights the importance of the vulnerability of the food systems that underpin food security to future scenarios of changed conditions. It also shows how policy and/or technical adaptation options designed to cope with the added stresses that GEC will bring to current food systems leads to adapted food systems; and that adaptation options will, in turn, feedback to socioeconomic and environmental conditions. Improved Decision Support Systems (DSS) are needed to help structure and enrich a dialogue on the nature of GEC/food systems issues between the research and policy communities, to help identify possible options to adapt food systems to the additional stresses GEC is bringing, and to assess the nature of feedbacks to the socioeconomic conditions and to the Earth System from possible adaptation options. DSS methods need to be established to enhance communication between GEC/food systems researchers and end-users to help guide the production and interpretation of information to help decision making.

DSS is one of the major research areas of Global Environmental Change and Food Systems (GECAFS), an international research program involving a wide range of social, physical and biological scientists, investigating the vulnerability of human food systems to, and interactions with, Global Environmental Change (GEC). The GECAFS goal is "To determine strategies to cope with the impacts of global environmental change on food systems and to assess the environmental and socioeconomic consequences of adaptive responses aimed at improving food security." DSS can help frame the necessary science-policy dialogue to deliver science and policy products appropriate to achieving this goal. In particular, GECAFS research aims to help in designing and interpreting more quantitative analyses of tradeoffs between environmental goals (including limiting deleterious feedbacks to environmental conditions and the Earth System) and developmental goals (including maximizing positive feedbacks to socioeconomic conditions). To this end, the overall GECAFS DSS framework will be used to assist in issue identification, information retrieval, scenario development and evaluation, and policy exercises that depend on multi-stakeholder negotiations and role playing. Initial GECAFS research in the Caribbean Region is using the Questions and Decisions (QnD) screening model system as one of the tools to help explore potential policy options related to food security, economic development and environmental management.

EC1.3

Active Fire Observations from MODIS to Support Decision Making

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The Moderate Resolution Imaging Spectroradiometer (MODIS) aboard the polar orbiting Terra and Aqua satellites of the NASA (National Aeronautics and Space Administration) Earth Observing System (EOS) has channels specifically designed for active fire detection. The MODIS Fires and Thermal Anomalies product has been generated systematically since late 2000 for use by resource managers, policy makers and the scientific community. The standard product includes an active fire and cloud mask, the Fire Radiative Power (FRP), quality assessment information and extensive metadata. Rigorous validation of the product is underway using coincident fire observations from higher spatial resolution sensors, yielding limits of detection and commission and omission error rates that are communicated to the users in the product documentation and peer-reviewed publications. An integral part of the MODIS fire program is the customized packaging and distribution of information for a wide range of users worldwide. In the U.S. a major operational partner is the USDA Forest Service. The MODIS Land Rapid Response System (MLRRS) was created to provide a rapid response to Earth science events, particularly quick information turnaround for fire management in the form of imagery and text files providing the location and limited auxiliary information of hot spots. A MODIS Web Fire Mapper, including web GIS maps, has also been developed as part of an outreach program to the fire applications community. Software for generating MODIS fire products has also been distributed for use in a number of operational regional monitoring systems based on direct broadcast MODIS data. The data record has been processed into global spatially and temporally aggregated datasets applicable for large-scale multi-year analysis and decision making. MODIS fire data have also been used as source data for fire emission modeling. Fire observations from MODIS are a NASA contribution to the objectives of the Fire Mapping and Monitoring theme of the international Global Observation of Forest Cover/ Global Observation of Landcover Dynamics (GOFC/GOLD) program. These goals include summarizing fire management and research information needs for the data providers, improving access to and use of fire data and information, standardizing satellite products and determining their accuracy, promoting research and development to improve information provision, and securing long term global operational monitoring of fires.

EC1.4

Assessing Impacts of Changing Land Use, Climate and Atmospheric Chemistry on Forests of the Chesapeake Bay Watershed

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The Chesapeake Bay watershed is protected by 21 million acres of forest cover. These forests remove ground-level ozone from the atmosphere to provide cleaner air, and retain deposited nitrogen to help maintain the water quality of the Chesapeake Bay and its estuaries. As long as the forests remain healthy and productive, and are not significantly reduced in area, the ecosystem services they provide will be sustained. Significant threats include land use change, climate change, and increasing exposure to ozone and nitrogen deposition. Land-use change has caused significant changes in forest cover throughout the watershed. Combined with prospective changes in species composition induced by climate change, effects of land-use change on watershed-scale biogeochemistry are significant. Under current conditions, Chesapeake Bay forests retain 88% of deposited nitrogen, allowing only about 1 kg/ha/yr to leach into more sensitive aquatic ecosystems. As the level of deposition rises, the retention rate declines dramatically because forest ecosystems under current N deposition are close to N saturation. As a consequence, the negative effects on downstream ecosystems increase. One positive consequence of nitrogen deposition is increased productivity of forest ecosystems that are deficient in nitrogen availability. Net carbon uptake by forests of the Mid-Atlantic region may be increasing by 23% from nitrogen deposition. The increasing concentration of atmospheric CO_2 also is a factor that increases productivity by 11%; however, this rate of increase is largely compensated by ground-level ozone pollution, which is damaging to many plant species. To assess these threats and evaluate potential responses, we integrate data from extensive forest inventories and intensive research sites with a regional-scale ecosystem process model. Data-model integration allows us to determine how changes in multiple environmental factors affect the productivity, carbon stocks, and nitrogen retention of the watershed's forests. Because of the many factors and their complicated interactions, it is a challenge to convey this information to policy makers and land managers in a way that informs decision-making. Here we present an example application of the integrated data-modeling system that supports the ongoing assessment of the Chesapeake Bay's forests, and the periodic assessment of the Nation's forest and required by the Resources Planning Act of 1974. The integrated data-model system will also support assessment products of the Climate Change Science Program under the goal to understand the sensitivity and adaptability of different natural and managed ecosystems and human systems to climate and related global change.

EC1.5

Designing Wetland Conservation Strategies under Climate Change

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Wetland conservation is a major environmental concern in the Chesapeake Bay region. Substantial losses due to land development and other factors have had profound impacts on the Bay's aquatic resources. Current conservation efforts fail to account for the impacts of climate change on sea level, which can affect the success of conservation efforts. Land use controls are essential to effective wetlands conservation. This study develops a methodology for evaluating public wetlands conservation investments that takes climate change into account, and demonstrates the methodology for the Elizabeth River watershed in Virginia under plausible sea-level rise and land use scenarios.

Given the large uncertainty about the non-market values of wetlands, we use a cost-effectiveness analysis framework as the fundamental structure of our study. Two measures of effectiveness are considered in our study. One is the total amount of wetlands. The other is related to the wetland functions. We use a tool for wetlands identification and planning that was developed by the Chesapeake Bay Program. The tool uses information on wetland type, surrounding land use, and external influences to generate scores for five major wetland functions: habitat provision, water quality improvement, flood protection, bank stabilization, and sediment control.

Because it is essentially impossible to confidently predict the future sea level rise and land use, we develop scenarios that establish probable upper and lower bounds on future conditions. Sea-level rise scenarios are constructed using projections for the southern Chesapeake Bay region and local information. We use 4 to 12 inches sea-level rise for 2030. We also construct land use scenarios for the area by considering land use change drivers and comprehensive plans for the region. The current landscape is represented as a regular grid of cells of 25 acres each. A revised cellular automaton (CA) model is used to generate development vulnerability indexes for all the cells within the watershed. Strict CA articulate the growth (or change) process in terms of highly localized neighborhoods where change takes place purely as a function of what happens in the immediate vicinity of any particular cell. But in our model, we identify four major drivers that influence the development possibility for each undeveloped land cell. The four drivers are immediate vicinity (8-cell neighborhood) land use, distance to shoreline, distance to primary roads, and distance to population centers. Three land use scenarios developed in our study, compact, dispersed, and nodal, are based on the development concepts used in the 2026 Comprehensive Plan of the City of Chesapeake, Virginia. We assign different weights to the four drivers to reflect the three land use scenarios. A random term is also added for each cell in order to capture influences other than the four major drivers. Based on literature and local information, we assign Markov transition probabilities to the land uses within the watershed. We rank all the available undeveloped land cells based on their development index and convert a certain percentage of them into developed land cells according to the transition probability we set. Because of the existence of the random term, we can run the Monte Carlo simulation to generate future land use scenarios.

Three management strategies are considered. The first allows private landowners to erect protection structures at the landward existing wetlands and has higher elevation than the wetlands. In this case, when sea-level rises, the wetlands can migrate inland to survive. The third relocates wetlands strategically by public acquisition of low value and low elevation lands for restoration. Candidate restoration sites are identified based on whether the present landscape still retains features that allowed it to support wetlands in the past. We use the results of the protocols for implementation of a GIS-based model for the selection of potential wetlands restoration sites in southeastern Virginia. The decision-making process we consider for wetland management strategy 2 and 3 is a parcel-based discrete-time process. At the beginning of each five-year time period, for each undeveloped land parcel, decision-makers need to decide whether to buy, not buy, keep, or sell. Under different scenario combinations, we use discrete stochastic sequential programming (DSSP) to model this process and compare different wetland management strategies. The objective of our DSSP model is to minimize the costs of the wetland management strategy. We consider the costs of buying the undeveloped land and the wetland restoration costs. In our study, the prices of undeveloped land are modeled as a function of the development indexes. One important advantage of DSSP is that it allows for explicit consideration of the a priori known probabilities of uncertain events. In the DSSP framework, we consider two types of uncertain events that may affect the decisions. One is the acquisition of new information about sea-level rise. We assume that new climate information will become available every five years. We simplify the information as indicating low or high sea-level rise and arbitrarily assign probabilities for them. The other type of uncertainty arises from the development probability of each undeveloped land parcel. It is necessary to consider this uncertainty, because when decision-makers consider whether to buy an undeveloped land parcel during any future time frame, they need to consider information about the likelihood that parcel will still be available. These probabilities are derived from the Monte Carlo simulations described earlier. Sensitivity analysis is conducted for important parameters of the model. The CPLEX module of GAMS is used to solve the DSSP problem. Base case values for important parameters are specified, under which compact and dispersed land development scenarios incur similar expected costs. The wetland conservation goal cannot be satisfied if nodal development scenario occurs. The result indicates that nodal development pattern should be avoided in order to reach the goal of wetland conservation. Sensitivity analyses are conducted for development percentage, high SLR probability, real land price appreciation, discount rate, budget constraint of stage I, and wetland restoration costs. Considering the base case result and the sensitivity analysis, compact and dispersed development scenarios are equally desirable while nodal development scenario should be avoided.

Our study provides a methodology for assessing wetland conservation strategies that takes climate change into consideration. We believe that sea-level rise is an important issue which affects the success and effectiveness of wetland protection efforts because of the low-lying feature of wetlands. This methodology can be applied to other areas with some adjustments based on local situations. Value of information (VOI) estimates can also be easily extracted from the framework presented in our study.

EC1.6

A Tool for Screening Projects for Risks from Climate Change

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Each year the World Bank reviews and initiates some hundreds of projects, many of which deal with activities that are likely to be sensitive to the impacts of climate change. Examples include loans or grants to improve irrigation systems, expanding rural infrastructure, agricultural reconstruction schemes or ecosystem conservation projects. The design teams encompass a wide range of skills but those skills usually do not extend to specialists in climate change and its potential impacts.

ADAPT is an assessment and design tool that provides a simple, non-threatening and quick way of assessing development projects for potential sensitivities to climate change. The tool is based on expert assessment of the threats and opportunities arising from climate variability and change. It provides a summary of the climate trends and projections at the project site; identifies components of the project that might be subject to climate risk; explains the nature of the risk; suggests options for reducing the risk and provides documents and contacts to help project designers follow up on any identified risks. Essentially, the tool mimics an initial consultation with a climate change expert. The tool is intended for project team members, both within the World Bank and within client countries, who do not have specialized knowledge of climate change issues. A prototype tool has been developed and tested with potential users through a series of focus groups.

A final version is under construction with an initial focus on agriculture, water and rural infrastructure issues. However, the approach and the software (based on Microsoft EXCEL and Visual Basic) is applicable to a much wider range of themes. The knowledge bases held within the tool are open ended and can be extended for particular regions or for new issues.

EC1.7

Ocean Climate Decision Making Systems for Predicting Catch in Pelagic Fisheries

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The development of three decision making systems for understanding and predicting catch variability in pelagic fisheries will be presented. Target species and fisheries include dolphin fish (*Coryphaena hippurus*) in the oceanic waters off South Carolina, king mackerel (*scombermorus cavalla*), sardine (*Sardinella aurita*), and gag grouper (*Mycteroperca microlepis*) in the coastal waters off southwestern Florida, and blue marlin (*Makaira nigricans*) in oceanic waters of the Bahamas. Satellite derived oceanographic data products (primarily sea surface temperature and ocean color from NASA and NOAA satellites) are being used to identify and define quantitative relationships between the distribution of fish and their apparent preferred habitats within their ecosystems. Evaluation of the development and coherence in time and space of such physical and chemical discontinuities as ocean frontal boundaries (temperature, chlorophyll, turbidity, etc.) related to coastal plumes, Gulf Stream circulation features (e.g. meanders and eddies), and water mass location is a critical aspect of this research. Part of this study is the development of image processing and visualization tools to evaluate and merge data that exist in different spatial and temporal resolutions, as well as, different spectral bands. This research involves a partnership between private industry (scientists, as well as the recreational and commercial fishing industries), two state agencies (South Carolina and Florida), and an academic institution (University of South Florida). An evaluation of what research, climate data products, and tools are needed to advance the development of decision making tools and systems in fisheries will be considered.

EC1.8

The Implications of Climate Change in the Management of Vulnerable Species: The Case Study of Polar Bears

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Polar bears (*Ursus maritimus*) are a universal symbol of Arctic ecosystems. They are part of the traditional lifestyles of coastal indigenous people in the Arctic, and as the apex predator, they are an indicator of the health of Arctic marine environments. All aspects of the life history of polar bears are tied to the sea ice. Our studies in the Beaufort Sea show that during winter and spring, polar bears prefer shallow ice covered waters over the continental shelf near the shear zone. As the ice melts in summer, most polar bears retreat deep into the polar basin where they utilize the stable perennial ice. This forces some polar bears to swim long distances to reach the offshore pack ice. Polar bears return to near shore waters with the formation of new ice in autumn. We have documented major changes in sea ice conditions in the Arctic Ocean over the past 25 years including longer summer sea ice melt seasons, larger areas of ice-free water in summer, and decreases in total sea ice volume and coverage of multiyear ice. These changes will likely have population-level implications for polar bears including reduced access to preferred forage habitats, reduced availability of stable sea ice denning habitats on sea ice, and increased wave-induced coastal erosion of preferred terrestrial denning habitats. Finally, loss of sea ice habitat may lead to a greater frequency of negative encounters between polar bears and humans. Polar bears of the western population in Hudson Bay, Canada, have already shown negative signs of a warming environment. If the current trend of diminishing sea ice continues, a 30% decrease in the world population of polar bears is anticipated within 50 years. But the short-term effects in regions like the Beaufort Sea are difficult to project because the food chain could be stimulated by increased solar absorption into the ice-free ocean during summer. Presently, the U.S. Geological Survey is leading a research study to ascertain how polar bears of northern Alaska are responding to the recent changes in Arctic sea ice conditions. Managers require knowledge of the effects on body condition, recruitment, population structure, and distribution in order to predict population level impacts of these changes. Given the current Arctic warming trend, a reevaluation of population status is necessary to ensure that fundamental management issues regarding subsistence and sport hunting, and industrial activities and tourism, are supported by sound science.

EC1.9

TNC's Adaptation Efforts in Conservation Landscapes: Models for Federal Land Managers?

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The Nature Conservancy follows three models when allocating resources to prepare conservation landscapes for the impacts of climate change. We support 1) ad hoc efforts by individual site managers, 2) hypothesis-testing experiments in "sentinel ecosystems" - those likely to experience abrupt transitions and 3) climate-adaptive action at our most "treasured places."

Here, we present examples of each approach to implementing climate-adaptive strategies that maintain ecosystem services without loss of biodiversity. We also assess their decision support needs and their effectiveness in engaging other landholders. Without compatible management practices, individual managers may take short-term actions that inadvertently foreclose long term climate-adaptive options that would benefit all.

Ad hoc efforts are effective where established land management practices are successful. Programs for invasive species, fire, and/or sustainable resource use can be modified to anticipate trends in climate and climate variability. Where existing ecosystem disturbances are not well managed, the challenge of tackling climate change is much greater. Successful local managers influence their peers by example.

Hypothesis-testing experiments in "sentinel landscapes" identify the vulnerability and resilience of landscapes and the thresholds at which they will radically change.

Landscapes such as coastal wetlands subject to sea level rise and arctic tundra subject to permafrost melt can not be managed in the long term for the preservation of their existing conservation or use values. They are managed to ensure a transition to valued and productive landscapes. Scientific discoveries are shared through peer reviewed literature, workshops and working groups of the International Union for the Conservation of Nature and the Convention on Biological Diversity.

Our Treasured Places Network will comprise high-profile freshwater, marine, forest, grassland, and arid land sites important to biodiversity and to humans. At each place we will bring together private landholders, public agencies, experts from universities and botanical gardens and climate change scientists to identify and manage climate-related risks. Importantly, participants will disseminate information on impacts and adaptation to inform and motivate policy changes. TNC is the largest private conservation landholder in the US, but our success in managing climate risks depends on our ability to engage private, state and federal landholders in similar efforts. Individual landholders can pursue ad hoc efforts and hypothesis-testing experiments, but protection of the places we individually treasure requires all the actors in those landscapes to work together.

EC1.10

Linking Health and Environmental Data in a Public Health Surveillance System

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The National Environmental Public Health Tracking Network will establish a national network of local, state, and federal public health agencies to tracks trends in priority non-infectious health effects. Around 2009, when fully functional, the national EPHTN will be an early warning system for the rapid identification of adverse health events related to environmental sources. NASA's Earth-Sun System science results and EPA data provide available information on the environmental contribution to chronic disease and predictive value based on coupled Earth system-chronic disease models.

Environmental public health tracking is the ongoing, systematic collection, integration, analysis, and interpretation of data about the following factors: 1 - environmental hazards, 2 -human exposure to environmental hazards, and 3 - health effects potentially related to exposure to environmental hazards. To satisfy the definition of a surveillance system the data must be disseminated to plan, implement, and evaluate environmental public health action.

As part of EPHTN the Environmental Health Tracking Branch, Division of Environmental Hazards and Health Effects, National Center for Environmental Health (NCEH), Centers for Disease Control and Prevention (CDC) is developing Health and Environment Linked for Information Exchange in Atlanta (HELIXAtlanta). This effort is demonstrating a process for developing a local environmental public health tracking (surveillance) network. This effort is a classic illustration of, "The process is the product."

HELIX-Atlanta follows standardized CDC practice in design and implementation of a surveillance program. This modality is the analog of NASA system engineering approach, but designed to meet the realities of epidemiology. The project has five discrete teams working with existing information systems to answer public health practice inquiries received from the public, policy-makers, and other stakeholders. Each team is integrating one or more existing health databases with selected environmental data. Several of the teams are examining air quality measures obtained from both EPA monitoring sites and from satellite estimates. Another environmental data source of interest is "skin" temperature from satellite. None of the environmental data sources are well suited for public health surveillance, but they are adequate to prove concept and methodology. They are also superior to the alternative of doing nothing. A sixth team, "Outreach", is charged with identifying target audiences and designing products and protocols specific to each audience.

C01.1

Climate and Coastal Communities: Improving the Decision-Making Process

Eileen L. Shea

This paper will provide an overview of the consequences of climate variability and change for coastal communities and resources and explore opportunities to improve the use of climate science information to support decision-making. The author will provide a quick review of the key coastal impacts identified in the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) and including:

- Direct impacts on ecosystems and communities (e.g., coastal inundation associated with sea level rise, increased ocean temperatures);
- The challenges of protecting public safety and critical coastal infrastructure in the face of climate-related extreme events (including tropical cyclones, droughts and floods); and
- The implications of climate-related changes in the availability of freshwater resources for coastal communities, ecosystems and key sectors such as agriculture, fisheries and tourism.

The author will use examples from Pacific Islands to highlight the ways in which information about year-to-year climate variability (e.g., ENSO) is already being used today to support decision-making in key sectors. The author will then explore some of the important lessons learned from this decade-long experience with ENSO-based climate forecast applications and as well as recent community-based climate vulnerability assessment and adaptation efforts in Pacific Island coastal communities as they relate to improving the use of climate information to support decision-making.

In this context, the author will attempt to identify some possible guiding principles for future climate science to support decision-making including, for example, the importance of:

- A collaborative, participatory process involving both the providers and users of climate information;
- A problem-focused approach to understand vulnerability and guide the design and development of climate information products;
- Place, context and history in understanding vulnerability;
- Contributing to community-based climate assessment and adaptation efforts as well as traditional international scientific assessments;
- Focusing on enhancing the resilience of coastal communities and ecosystems as an underlying objective;
- Addressing climate-related changes along a continuum of timescales from extreme events through seasonal-to-interannual variability to long-term changes such as sea level rise in order to meet today's needs as well as plan for the future;
- Developing and sustaining an integrated program of observations, research, modeling, assessment and education/outreach; and
- Taking an integrated perspective on the climate-environment-society system that recognizes cross-sectoral impacts, linkages and opportunities.

C01.2

Using Paleotempestology in Support of Decision Making Under Uncertainty of Hurricane Climate Variability

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A major advance in hurricane climate science during the past decade is the development of *paleotempestology*, a new field that studies past hurricane activity by means of geological and archival techniques (Liu, 2004; Liu and Fearn, 1993, 2000). Climate scientists, risk managers, reinsurance companies, and other stakeholders have used data from paleotempestology to inform their decision-making about hurricane risks along the U.S. coasts.

For any particular coastal location, uncertainty about the hurricane risk is exacerbated by the lack of reliable information on the return period of the rare but most extreme hurricanes. For example, it is impossible to determine, based on the historical record, whether landfall by a category 5 hurricane such as Andrew or Camille in New Orleans is a 100-year or 500-year event, because New Orleans has not been directly hit by a catastrophic hurricane during the past 150 years. Paleotempestology can quantify that uncertainty by generating long-term empirical records of catastrophic hurricane strikes that span up to 5,000 years, which can be translated into an estimate of hurricane return periods and landfall probabilities. The most useful proxy data have been overwash sand layers found in the sediments of coastal lakes and marshes.

Paleotempestology helps to quantify the hurricane risks on both the temporal and spatial dimensions. Proxy records from five sites along the Gulf coast have shown that each site was directly struck by catastrophic hurricanes about 9-12 times during the last 3800 years, implying a return period of approximately 350 years, or a landfall probability of about 0.3% per year. Data have also revealed that hurricane activity on the Gulf coast has varied on the millennial timescale, with a relatively quiescent period during the past 1,000 years preceded by a hyperactive period about 1,000-3,800 years ago. The much higher landfall probability during the hyperactive period—about 0.5% per year—may define the upper limit of hurricane risk within the spectrum of uncertainty for the Gulf coast. Furthermore, recent research from Cape Cod suggests that, over the past 3,000 years, hurricane activity in the Atlantic coast has exhibited an anti-phase pattern with that of the Gulf coast. The anti-phase pattern may be explained by long-term changes in the position of the Bermuda High and the NAO. Thus, paleotempestology can also help to generate hypotheses about climate mechanisms controlling past and future hurricane activity, and to predict hurricane risks under different scenarios of future climate changes.

C01.3

Sea Level Rise: A Trendy Perspective

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For the past 21,000 years sea level has been rising, overall, globally. While there are regions where the rate of post-glacial isostatic rebound exceeds the rate of oceanic rise, the overall evidence is for a modern rate of rise that is second in magnitude to that of the estimated rate during the period from 15,000 to 7,250 years before present and equivalent to that from 7,250 t0 5,550 years before present. This study reports on several new findings. One is a new mathematical method to compute reliable coastal trends from tide gage data time series. The second is to demonstrate that the rise of coastal sea level will increase coastal surge and extent of inland flooding while reducing the time for inundation to occur. The third is to demonstrate that the annual rise and fall of coastal sea level is a significant ocean basin phenomenon. Finally, storm induced surface gravity waves impacts are greatly enhanced with rising sea level. The modern rate of rise poses challenging problems for coastal developers, planners, managers and policy makers as coastal regions are exploding with people and housing. This report provides data dependent information to help coastal communities better plan for the present and future.

C01.4

Informing Decision Makers of the Potential Impacts of Sea Level Rise on the Coastal Region of New Jersey, USA

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Increasing rates of sea level rise caused by global warming are expected to lead to permanent inundation, episodic flooding, beach erosion and saline intrusion in low-lying coastal areas. Sea level rise is a significant and growing threat to the coastal region of New Jersey, USA and this study presents a comprehensive assessment of the expected impacts. We project future sea level rise based on historical measurements and global scenarios, and apply them to digital elevation models to illustrate the extent to which the New Jersey coast is vulnerable. We also characterize potential impacts on the socioeconomic and natural systems of the New Jersey coast. We then suggest a range of potential adaptation and mitigation opportunities for managing coastal areas in response to sea level rise. Our findings suggest that where possible a gradual withdrawal of development from some areas of the New Jersey coast may be the optimum management strategy for protecting natural ecosystems.

C01.5

Overview of Information Needed to Adapt to Rising Sea Level

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Rising sea level alters the consequences of many coastal decisions—but that does not necessarily mean that it justifies making a different decision than one would make if the sea was not rising. Consider, for example, a new house: If rents will cover the cost of construction after 10-20 years, the house is worth building even if sea level rise is expected to submerge the house 50 years hence.

The decision on floor elevation may be more sensitive: Adding one foot to the floor elevation might extend the life another 50 years—but doing so increases the construction costs, and would require residents to climb two more steps every time they enter. This extra cost is probably not great enough to prevent most people from adding a foot to the floor elevation if the only alternative is losing the house in 50 years. But the house could be elevated later, so today's decision is whether to add a foot to the elevation now, or defer the decision until later.

Governments must often consider the cumulative impact of many individual decisions: Are the benefits from higher elevations so great that a township should take the decision out of the hands of property owners and impose a higher standard? Or does extending the lifetime of coastal homes actually conflict with environmental goals, e.g., removing homes as the sea rises allows wetlands to migrate inland, otherwise these ecosystems will be lost. Are these issues isolated effects that can be addressed in a few cases—or are they so widespread or important that categorical policies are needed?

This presentation examines the information needs of four classes of decisions responding to sea level rise [author's role in brackets]:

- Elevation of existing homes [property owner]
- Local infrastructure responses to sea level rise [analyst]
- Conservancy protection of coastal ecosystems at sea level [analyst]
- Federal and state regulatory policies to protect natural shorelines [analyst]

For each of those decisions, the presenter will examine the importance and adequacy of each of the following types of information:

- Causes: Scenarios and probability distribution of future sea level rise;
- Effects: coastal elevations and shoreline sensitivity to sea level rise;
- Alternative responses:
  - Identification
  - Costs and Consequences
  - Governmental hurdles and inducements.
- Other Factors:
  - Science communication
  - Stakeholder capacity to digest the information.

C01.6

Sea Level Rise and Ground Water Sourced Community Water Supplies in Florida

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The EPA Global Change Research Program is investigating the possible effects of climate change on water quality. Global average sea level is rising more rapidly as a result of climate change, posing risks to estuaries, aquifers, wetlands, lowlands, beaches, and infrastructure.

Florida is home to roughly 17 million people, over 90% of whom are receive drinking water from groundwater sources. In order to determine if the state's groundwater-sourced water supplies might be vulnerable to rising sea levels and saltwater intrusion, we developed a vulnerability screening tool based on the DRASTIC vulnerability index. DRASTIC, developed by EPA and the National Water Well Association, identifies vulnerability to contamination from the surface based on seven measures (depth to aquifer, recharge rate, etc.) We modified the index to measure vulnerability to lateral salt water intrusion and added new factors such as proximity to the coast. We obtained data on the location of drinking water systems and the factors included in the DRASTIC index from the Florida Drinking Water Administration, and applied our modified index. In addition, we developed a "value" score for each system based on the number of people served and the availability of alternative sources of water; a system serving a large population with only one source of water would be high value; a system serving a small community with alternative supplies would be low value.

The presentation will cover preliminary findings for Florida and discuss how the scoring system could be applied in other coastal areas with appropriate modifications to account for data availability.

C01.7

Context and Climate Change: Lessons from Barrow, Alaska

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Amanda Lynch, School of Geography and Environmental Science, Monash University, Australia
James Maslanik, Colorado Center for Astrodynamics Research, University of Colorado, Boulder

With NSF funding, we have sought to help Barrow, Alaska, adapt to problems of climate change and variability by expanding the range of informed choices for the community. After exploratory discussions in Barrow in August 2000, we focused on the community's vulnerability to coastal erosion and flooding as the outstanding problem from the community's standpoint. Since then we have reported our findings at least annually to community leaders and the public through meetings, lectures, and radio interviews, and have sought their guidance for further research.

Our approach is intensive: centered on one community; comprehensive, incorporating the full range of factors affecting Barrow's risk and vulnerability; and integrative, emphasizing interactions among these factors in a series of extreme events including the most damaging, the great storm of October 1963. Extreme events provide a common focus of attention for diverse community members and researchers from different scientific disciplines. The payoffs are indicated by community members' willingness to continue collaborating with us, and in their decisions and actions informed by our research: an emergency management exercise based on the 1963 storm, platting an evacuation route inland, locating a new hospital site outside the 1963 flood area, designing the Barrow Global Climate Change Research Facility to withstand a storm of that magnitude, and fuller consideration of alternatives to additional beach nourishment, including planning and zoning, relocation, and retrofit of the utility corridor.

Our intensive approach also suggests reconsidering the connections between science, policy, and decision-making structures. First, profound uncertainties are inherent in unique interactions among the many factors affecting local risk and vulnerability. Science cannot significantly reduce these uncertainties, but can reconstruct and update local trends, clarify underlying dynamics, and harvest experience for policy purposes. Second, sound policies to reduce vulnerability must incorporate these profound uncertainties and multiple community values though rational decision processes, ones capable of evaluating policies as events unfold, terminating mistaken policies, and building on successes. Third, the community itself is in the best position to understand its own context, to decide on sound policies, and to take responsibility for them. In short, context matters in adapting to climate change and variability.

Overall, cognitive constraints may be the most important human dimension in climate change decisions. To make the most of our limited cognitive capacity, future research might factor the global problem into more tractable local problems, and help local communities network to diffuse and adapt the best working solutions.

C01.8

Climate Change and Coastal Cities: Information for Decision Making

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There are few information resources on the impacts of climate change and climate variability in urban coastal areas. This paper will report on a project that sought to fill that gap in a heavily populated, major urban center, the New York metropolitan area. This metropolitan area encompasses 31 counties across three states and has a coastline of nearly 600 miles. The project had two major components. The first was focused on research both into the information needs of metropolitan managers, policy and decision makers, and residents in the tri-state metropolitan area and into their patterns of information seeking and use. The second component was to apply this information in the construction of an on-line information resource focused on climate change impacts in the region. This system, the Climate Change Information Resources-NYC (or the CCIR-NYC), was from the start intended to serve not just as an information resource for the New York region, but also as an extensible prototype that can be updated and expanded as needed and can serve as a model for the delivery of information on climate change and variability and their impacts in other urban coastal areas. The CCIR-NYC can be found at http://ccir.ciesin.columbia.edu/nyc/.

C01.9

A Resource Manager's Perspective on Applications and Information Needs

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Coastal resource managers at the state and federal level make decisions related to the development, protection and restoration of the coastal zone within their jurisdictions. To make wise decisions, these managers need information on a variety of parameters related to climate change. The purpose of this presentation is to both identify the types of information needed by coastal and marine resource managers to make decisions as well as to provide feedback to scientists about the application of their research to the management community. The presentation will draw on and summarize the preceding presentations papers in the coastal component of Session 4.

CO2.1

Understanding the Future of Coastal Wetlands in the Face of Sea-Level Rise: Lessons from Coastal Louisiana

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The continued existence of extensive coastal wetlands in Louisiana, even in the face of sea level rise and locally high rates of subsidence, illustrates the resilience of these ecosystems. Remaining marshes maintain their position relative to tide through a combination of organic matter accumulation and periodic inputs of sediments from storms. Hurricanes such as Andrew and Katrina import sediments to brackish and salt marshes providing a much needed supplement to the vertical building process. In more organic substrates, hurricanes can physically disturb marshes but in fresher systems regeneration is possible. The marshes that remain in Louisiana show that it is possible to maintain suitable conditions for vegetative growth even in the face of accelerated sea-level rise if hydrologic conditions allow natural processes to continue. Major land loss in Louisiana has resulted from human manipulation and alteration of riverine and tidal flows. The lesson for other areas from those wetlands that survive in Louisiana is that marshes can survive sea-level rise if we give them a fighting chance.

CO2.2

SELVA-MANGRO: An Integrated Landscape and Stand Simulation Model for Predicting Mangrove Forest Growth and Distribution across the Everglades Coastal Margin under Changing Climate

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The near sea level elevation and flat slope of the protected Everglades ecosystem supports one of the largest contiguous tracts of mangrove forests and punctuates their potential vulnerability to rising sea level, hurricane strikes, and changes in freshwater runoff. These forests are subject to coastal and inland processes of hydrology largely controlled by regional climate, natural disturbances, and water management decisions. Mangroves are highly productive ecosystems and provide valued habitat for fisheries and shorebirds. Global warming has been projected to increase sea water temperatures and expansion that may accelerate sea level rise and increase tropical storm intensity that may further compound ecosystem stress of these coastal systems. Increases in relative sea level will eventually raise saturation and salinity conditions at ecotonal boundaries where mangroves are likely to advance or encroach upslope into freshwater marsh/swamp habitats.

A landscape simulation model, SELVA MANGRO, was developed as a decision support tool to evaluate the potential impacts of climate change and freshwater restoration on the quality and distribution of future mangrove habitat. The SELVAMANGRO model predicts changes in habitat type and environmental conditions of individual land units (1 sq ha) on an annual basis for the simulated landscape. MANGRO is an individual based model composed of a set of species based functions predicting the growth, establishment, and death of individual trees. MANGRO predicts the tree and gap replacement process of natural forest succession as influenced by stand structure and environmental conditions.

Model applications were conducted to forecast mangrove migration under projected climate change scenarios of sea level rise for the Everglades coastal margin with and without hydrologic restoration. A digital elevation model for south Florida parks and refuges comprising the Everglades was developed to predict the rate and fate of coastal inundation from sea level rise over the next century. Sea level rise was modeled as a function of mean annual tide records for Key West, FL projected into the 21st century with the addition of curvilinear rates of eustatic sea level based on low and high SLR estimates from IPCC findings. Model results show that species and forest cover will change over space and time with increasing tidal inundation across the simulated landscape for all sea level rise scenarios. Model runs show that freshwater marsh/swamp habitats will be displaced as the tidal prism increases over time and as it moves upslope. Under these modeling assumptions, mangrove habitat will increase over the next century under climate change and conversely, freshwater marsh/swamp is expected to decrease.

CO2.3

Using Climate Change to Information to Support Adaptive Coastal Conservation

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The very essence of conservation is that it is enduring—that resources and places are maintained in their natural state "forever." Doing conservation in an ever-changing environment like the coast has presents special challenges. Natural climatic events and physical processes are always shaping this dynamic environment—beaches erode and accrete, marshes are submerged or migrate inland as sea level rises, hurricanes periodically cause massive damage to coastal habitats and coral reefs, changing rainfall patterns and river flows effect estuarine circulation patterns. This presentation reviews how The Nature Conservancy is attempting to use climate-related information in its conservation planning work, then will discuss the very real challenges faced by conservation practitioners in adapting conservation practices to a more variable and rapidly changing climate.

C02.4

An Information Guide for Strategic Management of Coral Reefs in a Changing Climate

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Paul Marshall, Great Barrier Reef Marine Park Authority, Australia
Heidi Schuttenberg, James Cook University, Australia
Roger Griffis, National Oceanic and Atmospheric Administration, U.S.A.

This presentation will review preliminary findings of *A Reef Manager's Guide to Coral Bleaching*, a draft information source for managers and other decision-makers on strategies for management of coral reef ecosystems in the context of climate change. The *Guide* represents a collaborative effort led by the National Oceanic and Atmospheric Administration and the Great Barrier Reef Marine Park Authority to compile contributions from across the coral reef stakeholder community – including coral reef managers and research scientists from U.S. and international governments, academia, and non-governmental organizations. The collective information relates to the U.S. Climate Change Science Program's efforts under Goal 4 (understanding the sensitivity and adaptability of different natural and managed ecosystems and human systems to climate and related global changes) and Goal 5 (exploring the uses and identifying the limits of evolving knowledge to manage risks and opportunities related to climate variability and change).

The biological diversity and productivity of the world's coral reefs support fisheries, underpin dive tourism industries, protect coastal communities from storm waves and erosion, and contain a largely untapped wealth of biochemical resources. Yet over the past several decades, pollution, habitat destruction, disease and unsustainable fishing have led to declines in reef condition worldwide. Against this backdrop of conventional stresses, the threat of mass coral bleaching due to climate-related temperature anomalies has recently emerged as an area of critical concern.

The scientific consensus is that tropical seas will continue to warm over coming decades, increasing both the probability and severity of mass bleaching events. These scenarios pose particular challenges, since anomalously warm sea temperatures are beyond the control of coral reef managers. Yet, there are actions that managers can take to boost the long term resilience of coral reefs to climate variability and change. The global research and management community has begun to develop strategies for (1) identifying climate-resilient areas and enhancing their protection and (2) implementing strategies to boost ecosystem resilience. *A Reef Manager's Guide to Coral Bleaching* brings together the latest scientific knowledge and collective management experience to assist managers with information on how to respond effectively to mass coral bleaching events. It synthesizes science and management information, explores emerging strategies, and informs the ways managers deal with the complex human dimensions of these issues with an emphasis on pragmatic, science-based suggestions for adaptive management of coral reefs in the face of a changing climate.

C02.5

A Resource Manager's Perspective on Supporting Adaptive Management

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Ocean and coastal resource managers must routinely make decisions related to the protection, use and restoration of the coastal zone within their jurisdictions. To make appropriate decisions, these managers need information on a variety of parameters related to climate change. The purpose of this presentation is to both identify the types of information needed by resource managers to make decisions related to protection, use and restoration of marine resources, as well as to provide feedback to scientists about the application of their research to the management community. The presentation will draw on and summarize the preceding presentations in the coastal component of Session 4.

AQ1.1

Review of the Health Effects Potentially Associated with Projected Changes in Concentrations of Air Pollutants and Aeroallergens

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Introduction:

Because weather affects the development, transport, dispersion, and deposition of air pollutants, there is concern that climate change could affect the burden of illness and mortality associated with these gases and fine particles. Climate change can affect air quality directly through changes in chemical reaction rates, boundary layer heights that affect vertical mixing of pollutants, and changes in synoptic airflow patterns that govern pollutant transport, or indirectly through changes in biogenic emissions. Unraveling the relationships among weather/climate, air pollution, and health is complex. More is known about the potential impact of climate change on ground-level ozone than other air pollutants.

Methods:

Literature was evaluated on the associations between weather and adverse health outcomes from exposure to air pollutants and aeroallergens, and on how the burden of these disease are projected to change under a changing climate.

Results:

Climate change could impact local to regional air quality through shifting regional weather patterns and their associated statistics, increasing or decreasing anthropogenic emissions via changes in human behavior, and altering the levels of biogenic emissions as a result of higher temperatures and land cover change. However, establishing the scale and direction of change is challenging. Future air quality, especially at the local to regional level, will be moderated by background levels of a range of pollutants at the global scale. For example, background ozone levels have risen since pre-industrial times and this trend is expected to continue over the next 50 years. Assuming no change in the levels of ozone precursor emissions, the future occurrence of the requisite meteorological conditions will determine the frequency of "ozone episodes." When the necessary conditions occur, current air quality standards are projected to be exceeded. As many major cities reduce vehicle-based pollutant emissions, it is expected that urban levels of ozone will approach rural levels.

Increased concentrations of carbon dioxide and increases in temperature are projected to increase the growth rate of allergen-producing plants, the production and transport of pollen, and the length of the pollen season. Changes have been observed in some regions that are attributed to climate change. Air pollution may facilitate the penetration of allergens into the lungs, as well as increase the depth of allergen penetration; both of which could increase the risk of allergic diseases and asthma.

AQ1.2

Impact of Climate Change on Air Pollution Episodes in the United States

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One issue often overlooked in climate change discussions is the probable impact of climate change on air pollution episodes. It is well known, however, that weather is a key variable controlling the severity and duration of these episodes. Concentrations of pollutants are highly sensitive to winds, temperature, humidity, and other weather variables. For example, the anomalously hot and stagnant conditions in the summer of 1988 led to the highest ozone year on record in the northeastern United States. Concentrations of particulate matter (P.M.) are also strongly tied to weather conditions. As greenhouse gas concentrations increase and climate change takes place, the consequences for air quality and human health could be significant, but the magnitude of this effect is not known.

To provide policymakers with valuable information on this issue, we have launched a multi-institutional project called GCAP: Global Climate and Air Pollution. The goal of GCAP is to quantify the effects of 2000-2050 climate change on air quality in the United States. We will compare these effects to those of changing manmade emissions. Our approach is to apply present-day and future meteorological fields calculated by the Goddard Institute for Space Studies general circulation model (GISS GCM III) to the Harvard global chemistry-aerosol transport model (GEOS-CHEM). For a more accurate simulation of regional air pollution, we will also apply initial and boundary conditions from the global models to the CMAQ regional model.

As a first step in the GCAP investigation, we implemented tracers of manmade pollution (carbon monoxide and soot) into the GISS GCM and performed a climate simulation from the present-day to 2050. Our results show that the severity and duration of summertime pollution episodes in the Midwest and Northeast United States increase significantly by 2050 relative to the present-day. Pollutant concentrations during episodes increase by 5-10%, and the average episode duration increases from 2 to 3-4 days. These increases in pollution severity and duration are due solely to climate change in the model; they appear linked to a decline in the frequency of low pressure systems crossing southeastern Canada. These systems, and the cold fronts that accompany them, ventilate the Midwest and Northeast. With fewer cold fronts in the future model atmosphere, stagnation episodes last longer and pollutant levels build to higher values.

AQ1.3

Ozone Air Quality Management through Methane Emission Reductions: Global Health Benefits

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Methane and ozone are the second and third most important greenhouse gases after carbon dioxide. Tropospheric methane oxidation also contributes to the growing global background concentration of surface ozone, an air pollutant associated with premature human mortality. Mitigation of methane emissions therefore decreases surface ozone everywhere while slowing climate warming, yet methane mitigation has not been considered for air quality management.

Here we estimate the effects of methane mitigation on global surface ozone concentrations, and the consequent global decreases in premature mortality. Relative to a baseline scenario from 2000 to 2030 (based on IPCC SRES A2), we apply a 20% reduction of global anthropogenic methane emissions (65 Mton CH_4 yr^{-1}) starting in 2010. Using the MOZART-2 global atmospheric chemistry-transport model, we estimate that this methane reduction would decrease 8-hr. surface ozone by ~1 ppbv (part per billion by volume) globally. The global reduction in premature human deaths resulting from these surface ozone decreases are then estimated using epidemiological relationships. We combine the simulated daily spatially-distributed decreases in surface ozone with estimates of future population, to estimate the global incidences of premature mortality prevented by the methane reduction. Results are expressed both as avoided premature mortalities and as monetized benefits per ton of methane reduced.

Our results indicate that methane emission control is a viable approach to long-term ozone management, with benefits that are shared globally. Methane mitigation therefore offers a unique opportunity to manage air quality globally, while slowing greenhouse warming, improving public health, and increasing energy supply.

Fiore, A. M., D. J. Jacob, B. D. Field, D. G. Streets, S. D. Fernandes, and C. Jang (2002), Linking ozone pollution and climate change: The case for controlling methane, *Geophys. Res. Lett., 29(19),* 1919.

West, J. J., and A. M. Fiore (2005) Management of tropospheric ozone by reducing methane emissions, *Environ. Sci. & Technol.*, 39(13): 4685-4691, doi: 10.1021/es048629f.

West, J. J., A. M. Fiore, L. W. Horowitz, and D. L. Mauzerall (under review) Mitigating ozone pollution with methane emission controls: global health benefits, *Proc. Nat. Acad. Sci.*

AQ1.4

EPRI Workshop on Interactions of Climate Change and Air Quality: Findings and Recommendations

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Better understanding of the interactions between climate change and regional air quality is an emerging priority for environmental policy. Aerosols and ozone, the two principal air pollutants in the developed world, also affect climate in important and complicated ways. In turn, changes in climate may have profound implications on air quality through perturbations to winds, mixing depths, temperatures, and other meteorological variables. Climate change will also affect emissions associated with fires, dust storms, lightning, and the biosphere, as well as the atmospheric deposition and ecosystem cycling of bio-accumulating pollutants such as mercury. Better understanding and assessment of the linkages between air quality and climate change is needed to develop joint mitigation approaches that are overall more effective. This will require accurate physical models that account for the interactions between atmospheric components and climate on global to regional scales. Presently, there are major gaps in scientific understanding that limit the development of such models. In order to identify the critical research priorities, the Electric Power Research Institute (EPRI) convened a workshop in April 2005 with participation of a broad range of scientific experts. We present here the key findings and recommendations from the workshop, including in particular the identification of specific gaps in knowledge where focused research programs would earn large dividends for improved decision making.

AQ2.1

Towards an Integrated Observing System for Air Quality Decision Making

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The recent U.S. CCSP Strategic Plan declares a goal to increase knowledge of the interactions among (air) pollutant emissions, long range transport, climate change, and air quality management. Under UNESCO, the international science community has outlined a decennial plan (Integrated Global Atmospheric Chemistry Observations) for an atmospheric chemistry observing system, the tools to integrate observations and models, and a structure to make these results accessible for decision making. On a regional scale, the U.S. Environmental Protection Agency (EPA) sets National Ambient Air Quality Standards for Criteria Pollutants [ozone, carbon monoxide, nitrogen oxides, sulfur dioxide, mercury, and aerosols] (Clean Air Act, 1970 and Amendments), and provides surface monitoring in urban areas. NASA's Applied Science program has supported the technical evaluation of space based observations of criteria and related pollutants in partnership with U.S. EPA (NASA National Applications Program Plan and Agency Deliverables). This work includes evaluating satellite products from NASA's newest missions, and prototyping the use of satellite data in daily efforts to predict, manage, and mitigate the harmful effects of air pollution.

Aerosol and trace gas pollution from human activities and large-scale wildfires rise above the boundary layer and can travel great distances, sometimes returning to the surface at sites geographically and jurisdictionally distant from the sources, due to the effects of weather and chemical processes. This complex behavior of trace atmospheric constituents that affect human health and ecosystems can be understood fully only with an integrated observing system that comprises process studies, source/point data, global observations, and time-resolved observations.

This paper reports specific efforts toward integrating observations of atmospheric chemistry from space and Earth's surface with adequately resolved models of atmospheric chemistry and transport, to attain the ultimate goal of air quality decision making support: ubiquitous, near-surface atmospheric trace gas concentration. In the past, climate change studies in atmospheric composition have focused on the composition of the upper atmosphere (ozone hole), with large spatial scales and long time scales. From the perspective of public and individual decision making, air quality is boundary layer composition throughout the day. We will discuss the capability of present systems to meet this challenge and offer suggestions for future investments to support decision making.

AQ2.2

Integrating Climate Modeling and Remote Sensing Data to Improve Public Health Decision Support Tools – Part I

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On December 15 and 16, 2003, a dust storm occurred over New Mexico and west Texas as a strong Pacific cold front brought gale-force winds through the region. Combined with existing dry conditions, this system caused one of the worst dust storms in the area in recent years. Dust events such as this can adversely affect patients with known respiratory conditions. Early warning of these events would better prepare clinics, hospitals, and health care officials in responding to the need of these patients.

NASA's partners at the University of New Mexico, University of Arizona, Texas Tech University, and Sandia National Laboratories are using an NCEP/Eta-based model and satellite data to develop a dust forecasting tool that alerts public health officials to environmental events affecting patients with high risk respiratory conditions. Dust storms and smoke from forest fires can extend for hundreds of miles over a region. Data collected by a host of satellites and in-situ ground stations, coupled with weather models used by the National Weather Service and visualization technologies, offer a new dimension of information for providing health risk alerts. Working closely with the public health communities in Arizona, New Mexico, and Texas, the project aims to provide a module that can be used within existing desk-top decision support tools such as the Rapid Syndrome Validation Project (RSVP).

This presentation will provide an overview of the project and its relationship to the goals and objectives of the CCSP Strategic Plan on "Decision Support Resources Development." The discussion also will describe how NASA data are being introduced to improve a dust forecast model, the Dust Regional Atmospheric Model (DREAM), which is producing products for improving a public health decision support tool developed by Sandia National Laboratories. Finally, methods for communicating this scientific information will be discussed, including web mapping and visualization technologies.

AQ2.3

Supporting Long-Term Regional Air Quality Management in Response to Global Change

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Energy often enters into local, state, and regional planning. For example, the ability of industries to adapt to future changes in fuel availability and prices is important in ensuring that an area will be economically competitive in the future. Energy is also important in environmental planning; the energy system plays a critical role in urban- and regional-scale air quality management since combustion is the major anthropogenic source of nitrogen oxides (95%), carbon monoxide (95%), sulfur oxides (89%), ammonia (62%), and mercury (87%). Thus, any policies targeted at acid rain, tropospheric ozone, fine particulate matter, or mercury will undoubtedly affect the energy system. Similarly, land use planning and water resource management often have energy implications.

In this context, decision-makers should have sound tools for evaluating energy in environmental planning. Developing such tools, with a focus on air quality, is an objective of EPA Office of Research and Development's Global Change Air Quality Assessment. EPA entered into a cooperative agreement with the Northeast States for Coordinated Air Use Management, or NESCAUM, to develop a regional version of the MARKet ALlocation energy system model and technology database (NE-MARKAL). NE-MARKAL incorporates characterizations of energy supplies, energy demands, and energy-related technologies for the six New England states. Sectors represented include electricity generation, industrial, commercial, residential, and transportation. The model identifies cost-effective technology pathways for meeting future energy demands and emissions constraints. NESCAUM plans to apply NE-MARKAL to assess a variety of multi-pollutant management strategies and regional policy commitments. Results will inform EPA on the merits of a national versus regional approach.

To facilitate regional analyses, EPA has developed a prototype decision support system that links NE-MARKAL to a response surface model, or RSM, and a health benefits model, BenMAP. The RSM is a statistical representation of a regulatory-scale photochemical grid model. BenMAP is an EPA model for estimating the health benefits associated with changes in air quality. This linkage allows quick screening of future energy system technology scenarios to estimate and visualize their impacts.

During the presentation, NE-MARKAL will be described and its linkage to the RSM and BenMAP within a prototype decision support system will be demonstrated. Future directions will be discussed.

AQ2.4

Application of an Integrated Modeling System for Climate and Air Quality Change Studies at Regional to Local Scales

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A state-of-the-art integrated modeling system has been developed to provide credible information at regional to local scales on climate and air quality, including their variability, change and impact, as a scientific basis for decision makers to select optimal pathways. This system is currently being applied, with support from the EPA Science to Achieve Results (STAR) Program, to quantify and understand the uncertainties of the individual and combined impacts of global climate and emission changes on U.S. air quality, from the present to 2020, 2050 and 2100. We present recent results over the U.S. that demonstrate the system skill in downscaling the present climate (precipitation and surface air temperature) and air quality (ground-level ozone), as well as the uncertainties and credibility of future projections. The appropriateness and limitations of the modeling system for decision making at regional to local scales are evaluated.

It is shown that the dynamic downscaling can significantly reduce biases of the driving global models in simulating the present climate/air quality patterns and that this improvement has important consequences for future projections of regional climate/air quality changes. For both the present and future climate simulations, the regional modeling system results are sensitive to the planetary forcings imposed by outputs from different global models as well as to its own physical process representations, especially different cumulus parameterizations, with strong regional dependence. Due to these sensitivities, there are large uncertainties involved in application of model projections of future climate/air quality changes for decision making at regional to local scales. Given significant uncertainties in estimating/projecting surface emissions and important contributions from long-range pollutant transport, decision making on U.S. air quality regulation is challenging.

AQ2.5

Development and Evaluation of a Methodology for Determining Air Pollution Emissions Relative to Geophysical and Societal Change

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The evaluation of future air quality critically depends on the specification of future emissions. Technological change, which is typically reflected in different scenarios, can have a large impact on future emissions. A less well appreciated factor that influences emissions is structural economic changes such as outsourcing of goods and services. The focus of the present research is on developing an Emissions Inventory Modeling System (EIMS) that uses regional econometric models and emissions development tools to formulate future emissions inventories for different social and climate change scenarios. Changes in population, economy, policy and regulations, technology development, transportation systems, energy systems, landscape and land-use, and vegetation and land cover are considered. Results are reported for analysis of future emissions in the Chicago area in a format consistent with the USEPA's National Emissions Inventory (NEI), and the methods are being expanded to develop emissions for the Midwest. A baseline case incorporating future economic development out to 2030 with present emission technologies is presented to isolate the effects of structural economic change on emissions. Future total emissions and the impacts from each economic sector are analyzed. In addition, an analysis of the impact of heavy duty diesel rule on economy and emissions is conducted. The methodologies used to interface emissions and control technologies with the econometric model are discussed.

EN0.1

Brief Overview: CCSP Activities Informing Decision Making

Jerry Elwood, U.S. Department of Energy, jerry.elwood@science.doe.gov

EN0.2

Brief Overview: CCTP Activities Informing Decision Making

David Conover, U.S. Climate Change Technology Program/U.S. Department of Energy, david.conover@hq.doe.gov

This breakout session is tasked with identifying the information that is needed from the Climate Change Science Program (CCSP) to guide and support the research, development and deployment activities related to greenhouse gas intensity reducing technologies. Part of the Climate Change Technology Program (CCTP) mission is to accelerate the development of these technologies, create options and reduce their costs, so as to facilitate progress in addressing climate change concerns. As Director of CCTP, Mr. Conover will provide an overview of the CCTP, its goals and plans, and suggest a framework for discussion by the panelists and the audience. He will start with the UNFCCC as the overarching context, which is tied to the question of determining the concentration of GHGs that would prevent dangerous anthropogenic interference with the climate system. He will note that the application of such frameworks begets further complexities and many different variables, which CCSP research can help to illuminate.

EN1.1

Climate Science Applications to Support Short-Term, Operational Decision Making for a Utility and for Financial Commodities Trading

David D'Arcangelo, Cinergy Corporation, Cincinnati, OH, David.D'Arcangelo@Cinergy.com

Energy companies engaged in the financial transaction and provision of electricity and natural gas to consumers are highly susceptible to short and medium term weather changes. Moreover, the increased volatility of energy prices in recent years coupled with the rising demand from the residential sector mandates more accurate forecasts of system load in order to take advantage of or be hedged against extreme events. More accurate prediction of temperature, cloud cover, dew point and tropical events pays large dividends in the financial markets and in being able to serve customers reliably. Advances in 1-15 day forecasts would be have the most immediate impact; while more accurate skill at ranges of out to 3 months would enable better long-term planning. More complex statistical forecasts should be promoted at all forecasts ranges to allow energy companies to simulate scenarios of system demand and price on various weather events.

EN1.2

NASA Satellite Measurements and Modeling Contributions to Decision Support in the Energy Sector

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The Prediction of Worldwide Energy Resource (POWER) project, conducted at the NASA Langley Research Center, seeks to expand the use of global weather and solar energy information in energy-related industries by interacting with partners to benchmark NASA research data sets derived from the analysis of historical and current observations. Four of these industries have been identified and targeted for use of NASA analysis and modeling data:

- **Renewable Energy Production**: assist energy producers in locating optimum sites for Renewable Energy Technologies (RETs).
- **Building Design**: assist architects and engineers in understanding the seasonal environment a building must endure and design to optimize energy usage.
- **Biomass Fuel Development**: assist farmers in planning, monitoring, and predicting yield of various fuel crops.
- **Energy Utilities**: assist utility companies in the decision-making of buying and selling power.

The POWER project contribution consists of developing pathways of environmental information that assist designers and planners to develop decision support systems (DSS) which are optimized for their local weather and climate conditions and to assist planners and managers in the maintenance and operation of these systems. These elements are specifically identified in both the Climate Change Science and Technology Programs' (CCSP/CCTP) strategic plans and contribute to the priorities of the United States Group on Earth Observations, the Global Earth Observation System of Systems, and the G8 Gleneagles Plan of Action on Climate Change, Clean Energy and Sustainable Development.

The POWER project uses the NASA Surface Solar Energy (SSE) data set and adds near-real time and forecasted datasets to the historical datasets. The project has developed prototype pathways to deliver data important to renewable energy system design in partnership with Natural Resources Canada's renewable energy DSS, RETScreen, the National Renewable Energy Laboratory's Hybrid Optimization Model for Electric Renewables (HOMER) DSS, and the photovoltaic sizing tool, SolarSizer, maintained by SoL Energy. These activities have also contributed to the United Nations Environment Programme (UNEP) Solar and Wind Energy Resource Assessment (SWERA). SWERA provides solar and wind resource data and geographic information assessment tools to the public and private sectors in 13 developing countries.

EN1.3

Climate Forecasts for Improving Management of Energy and Hydropower Resources in the Western U.S.

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David Pierce, SIO
Anne Steinemann, Univ. of Washington
Nathalie Voisin, Univ. of Washington

We evaluate how climate forecasts can be used to predict variability that jointly affects water and hydropower supply, and electricity demand, in the Western U.S., enabling more efficient management of hydropower and energy resources. We will present the results to date of our model development, evaluate the appropriate scale of decision making they support, and describe our stakeholder partnerships.

Regional hydrologic forecast models used to manage hydroelectric power resources in California (CA), the Columbia River basin of the Pacific Northwest (PNW), and the Colorado basin in the Southwest (SW) rarely incorporate climate predictions. Instead they use midwinter snow pack measurements, and have no skill beyond climatology prior to midwinter. Furthermore, these methods have generally been applied at local rather than regional scales. Rudimentary models predict effects of weather on the energy industry, but these methods use climate forecasts in only a very crude way or not at all. Little or no effort has been made to jointly predict both water and energy variations across the West on seasonal time scales; addressing both regionally in an integrated way is a unique feature of our project. Joint prediction of water and power generation potential and electricity demand is critical, given the large role hydroelectric power plays in the economy of the western states.

In CA, for example, hydropower resources in CA and energy transfers from the PNW and SW represent energy that will not have to be produced in CA using natural gas turbines or other fuel based technologies, and these resources play a role in determining the risk of capacity related failures. Preliminary studies examined the seasonal predictability of hydropower resources in the PNW and CA, and also of natural gas usage. The most important findings of these studies are that surplus energy in the PNW is strongly related to interannual variability of ENSO and PDO, hydropower resources in CA and the PNW have tended to covary in recent decades, amplifying the impacts of hydropower variations in the West, and there is a strong link between regional hydropower capacity and natural gas usage. In the current phase of the project, we are developing forecasts of system wide hydropower production using linked hydrologic and reservoir simulation models, in conjunction with forecasts of western electricity demand. The economic impact of climate variability on the western power system will be evaluated by the Western Electricity Coordination Council (WECC) using their regional energy production and transmission model.

EN1.4

Translating Research Results into Resource Plans at the State Level

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The state of California periodically produces long-term planning documents such as the State Water Plan and the Integrated Energy Policy Report. The State Water Plan is updated every five years and the Energy Plan every two years as mandated by state law. Both plans contain generic discussions on climate change but additional scientific information will be needed to make specific policy recommendations.

Climate change has the potential to affect water and energy resources in California and increase summer peak electricity demand while decreasing cooling demand in the winter season. Preliminary studies suggest that net energy expenditures in California will experience an increase that cannot be mitigated by reduced energy expenditures in heating demand. The increased urbanization in the hot interior of California will result in a disproportional increase in expensive peak energy demand. At the same time, a reduced snowpack in the Sierra Nevada will result in less hydropower production during the spring and summer months when this source of electricity is most needed.

Scientific research has been helpful in making policy makers aware of the problem and the need to adapt and mitigate any adverse effects due to increased climate variability and change. However, the tools and information needed to develop action plans are not available. To try to address this situation, the state has created a virtual research center on climate change known as the California Climate Change Center. Core research activities are underway at Scripps Institution of Oceanography and at the University of California at Berkeley. The goal of the Center is to complement the national research program with policy relevant research to provide the information needed for long-term state planning. For example, water and energy agencies in the state have indicated that the development of probabilistic climate projections for California at adequate levels of geographical and temporal resolution for both research and planning work should be a priority. The Center is striving to produce such projections.

This presentation will provide some suggestions on how state funded research efforts could be enhanced by additional coordination with the national research program. The NOAA RISA program at Scripps is an example of this type of collaboration. Strong collaboration between the federal and state research programs will also ensure the relevance of the U.S. Climate Change Science Program on state and local level decision-making in California.

EN2.1

Science Needs to Inform Long-Term Decision Making in the Energy Sector

Presenter TBD

This paper will examine the impacts of alternative constraints on greenhouse gas emissions on the future configuration on the global energy system. It will discuss the role of global warming potentials (GWPs) and the importance of the choice of the metric for stabilization (emissions, CO_2, radiative forcing, temperature) on the timing of GHG reductions.

EN2.2

Improving Climate Information for Hydroelectric Dam Relicensing

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Rapid population growth combined with a recent four-year drought has heightened concerns over water supply and quality in North and South Carolina. As demand grows and water systems increasingly face quality issues, interannual and interdecadal climate variability, as well as the potential for longer-term climate change, will play an increasingly important role in water resource management. The relicensing of numerous dams on Carolina watersheds by the Federal Energy Regulatory Commission (FERC), provides an unique setting for understanding how climate information can be incorporated into operational decisions and planning. Consideration for climate variability and change makes sense given the 30-year duration of the new licenses. This paper reviews the ways in which climate variability and change have been incorporated in interstate water negotiations and the FERC relicensing process. Typically, the FERC process requires a reservoir operations model that allocates water according to a range of optimizing criteria. In some relicensing examples, climate has been considered only implicitly by these models. For example, some simulations have used historic reservoir levels as input to a reservoir operations model. Such data are often of poor quality compared to USGS streamflow records. A more thorough, explicit consideration of climate variability and change would involve hydrologic streamflow modeling. While not adopted in many relicensing negotiations, this approach allows consideration for a wide range of future climate conditions. We will also discuss examples in which treatment of climate information evolved in response to specific stakeholder requests. Recently state agencies requested improved methods for determining low-inflow protocol triggers. This prompted examination of long-term precipitation and streamflow records, and shift from state-level drought assessment to more locally defined triggers. Finally, we will review examples where stakeholders have argued about what defines a climatic anomaly and how extremes should be treated in management and planning.

EN2.3

Planning Bio-Energy Options: Climate Feedbacks And Information Needs

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Bioenergy has been forecast to play a significant mid-term role in reducing global greenhouse gas emissions and it is the only solution for liquid transportation fuels. Bioenergy could supply 100 to 400 EJ/yr by 2050. While bioenergy is not usually greenhouse gas neutral, it can have much lower net greenhouse gas emissions than its fossil fuel counterparts. The greenhouse gas benefits are strongly feedstock and conversion technology specific. Decisions to exercise the bioenergy option must take into account that while the option could reduce climate change by reducing greenhouse gas emissions it will also be impacted by climate change. This impact comes about because bioenergy is constrained by feedstock availability, which is a function of plant productivity and land availability, both of which are affected by climate change. Productivity will be directly affected by climate change while land availability will be indirectly affected as climate change alters competing land demands for food, fiber and conservation. CCSP research on land use/land cover change, ecosystems, and human contributions and responses to environmental change will help inform our ability to effectively exercise the bioenergy option.

EN2.4

Science for Carbon Management: Making Effective Connections Between Users and Producers of Information

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The Carbon Cycle Science element of the Climate Change Science Program (CCSP), especially the North American Carbon Program (NACP), has a stated goal of providing near-term information of use to decision makers. Carbon management is a relatively new concept—while carbon management has only been seriously discussed for a few decades, water, land and marine resources have been actively managed by society for centuries. The carbon cycle science community therefore does not have a wealth of experience from which to draw upon in trying to develop a scientific agenda that will successfully meet the needs of decision makers. Moreover, as demonstrated by several other areas in Earth science, scientific research does not necessarily generate information that is useful to anyone outside of the scientific community. For example, attempts to provide climate forecasts as a service to farmers and other natural resource managers have disappointed: the information provided was not needed; the information that was needed was not provided; the information lacked regional specificity; the presentation and communication tools did not make the information accessible to potential users; potential users lacked trust in information and researchers; institutional constraints prevented use of new information; and so on. Experience has shown that deliberate research strategies including ongoing involvement with users may be necessary to avoid these disconnects.

The existing research strategy of the carbon cycle science program does not yet have a focus on ensuring that its research results will be useful to decision makers outside the scientific community. We are an interdisciplinary team that has been engaged in research and dialogue with members of the potential carbon management stakeholder community, including the energy sector, in order to improve the usefulness of carbon cycle science for decision makers.

The presentation will focus on what we have learned thus far from working with stakeholders on the State of the Carbon Cycle Report (SOCCR), slated to become CCSP Synthesis and Assessment Product (SAP) 2.2, and through dedicated workshops with potential users, carbon cycle scientists and science policy experts. It is clear that in some specific circumstances, carbon cycle information is being used. In other situations, information might be needed but is not being provided, either because it doesn't exist or it is being insufficiently "translated"—clearly a "missed opportunity." In this presentation we will conclude with some potential steps forward to capitalize on this opportunity, including options for structuring research, institutional implications, and lessons learned.

EN2.5

The Future of Integrated Assessment Modeling as a Decision Support Tool for Energy and Climate

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We are now entering a new era for climate change technology, implementation. As we contemplate this phase there are three important aspects of the challenge that will face decision makers. First, over the course of the next century, the changes, particularly in the energy system, required to stabilize greenhouse gas concentrations are massive. Second, the changes in the energy system will be occurring in the face of other policy challenges, such as energy security and regional air quality. Finally, the increased importance of renewable energy, the non-uniform distribution of sequestration and carbon storage options and the differing national pressures associated with energy matters will force energy solutions to be regional and highly integrated.

The integrated nature of future energy strategies associated the greenhouse gas emission mitigation is reflected in more than the classic integration of large-scale energy systems. It will involve integration with respect to resources, such as land and water, and related policies. Given uncertainties with respect to the many parameters that may affect decisions on energy systems ranging from the climate itself to the variety of other policies that may affect energy, the challenge is large. Future systems will need to match the complex decision-making environment and incorporate advances from modeling to data acquisition and analysis.

This presentation, made from the perspective of the leader of a major group of developers of decision support tools, will highlight the need for increasing regional and multi-resource tools. It will highlight how the science of integrated assessment from CCSP will need to grow to meet the eventual deployment challenge facing CCTP.

EN2.6

Tools for Interactive Decision Making under Uncertainty on Energy and Climate Change

Jurgen Scheffran, University of Illinois, scheffra@uiuc.edu

A framework for interactive decision making under uncertainty will be presented that integrates tools from time-series analysis, probabilistic Bayesian learning, control theory and dynamic games to provide decision support in negotiations and stakeholder dialogues on mitigation and adaptation of climate change. Actors can choose targets and actions on issues such as emission reduction, emissions trading, energy technologies, carbon capturing and sequestration, technology transfer and financing. Target setting takes into consideration the selection or exclusion of certain system states or trajectories based on uncertainty analysis, probabilistic scenarios and risk assessment of dangerous climate change. Actions are selected according to behavioral rules that depend on the targets, the state of the environment and actions by other actors. In feedback cycles the actors mutually adjust investments according to strategies and learning mechanisms which include cooperative control and coalition formation. This approach provides elements for an integrated assessment of climate, economic and policy modules. A specific case will be presented for decision-making on energy, using a new database on population, GDP, energy and carbon emissions, and uncertainty estimates of carbon intensity and climate sensitivity. For given global limits on carbon concentration and temperature, emission trajectories are determined and strategies for investment in energy systems, including technology transfer and cooperation between industrialized and developing countries.

P-DS1.1

CCSP Poster on Synthesis and Assessment Product 1.2: Past Climate Variability and Change in the Arctic and at High Latitudes

Thomas R. Armstrong, U.S. Geological Survey, tarmstrong@usgs.gov
Joan Fitzpatrick, U.S. Geological Survey

The Arctic and the high latitudes have warmed more rapidly than almost any other region on earth over at least the last millennia. This warming has been accompanied by a decrease in sea ice cover and thickness and a decrease in ocean salinity. In addition, the permafrost has melted significantly in recent years. The impacts on humans and ecosystems that are associated with these changes were recently reported in the Arctic Climate Impacts Assessment. This international study was partially funded by CCSP-participating agencies. The Arctic and High Latitude Synthesis and Assessment Product (SAP) will focus on the state-of-knowledge concerning past changes in the physical climate of this region. This information is vital since high latitude regions also are projected to experience the greatest warming in the future.

The prospectus is currently being developed for this report and the bulk of the work will be carried out in FY 2006. The report developed during this assessment will include a conceptual framework from which both future research directions and related management actions can be addressed, vetted, and ultimately developed. The report will lead to a better understanding of the causes, interconnections, and feedbacks related to past, present, and future arctic and high-latitude climate changes and the physical responses that occur as a result of these events. This presentation will provide information concerning the scope of the SAP, key issues to be addressed, the scope of the intended audience, the SAP development schedule, the processes for its development, and opportunities for public input and scientific review.

P-DS1.2

Climate Projections for Research and Assessment Based on Emissions Scenarios Developed through the CCTP – Synthesis and Assessment Product 3.2

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The Earth's climate system derives its energy from the Sun and any variations in the energy being received at the surface can change the climate. Variations can be caused by natural factors, such as changes in solar output and volcanic eruptions, or by anthropogenic changes in atmospheric concentrations of long-lived greenhouse gases, aerosols, and other radiatively active short-lived species. Computer simulation models of the coupled atmosphere – land surface – ocean – sea ice system are essential tools for understanding past climates and making projections of future climate resulting from radiative forcing changes, both natural and anthropogenic. Projections of future climate require estimates, e.g. scenarios, of future emissions of greenhouse gases, aerosols, and other short live- species. A number of such standard scenarios have been developed for the IPCC Assessment process, and the future impacts of these have been explored. As part of the CCTP and CCSP process, updated scenarios of greenhouse gases and Atmospheric concentrations are being developed by Synthesis and Assessment Product 2.1.

Some of the likely topics which will be discussed in Synthesis and Assessment Product 3.2 include:

- What is the process in going from emissions scenarios to fields of time and space varying radiative forcings for the various constituents needed to force the climate models?
- What would be the changes to the climate system under the scenarios being put forward by Product 2.1?
- For the next 50 years or longer can the time varying response of the projections using the emissions from Product 2.1 be distinguished from one another or from the scenarios currently being used by the IPCC?
- What are the impacts of the radiatively active short-lived species not being considered in Product 2.1; what would be the climate impacts of mitigation actions taken to reduce their atmospheric levels to address air quality issues?

P-DS1.3

CCSP Poster on Synthesis and Assessment Product 3.4: Risks of Abrupt Changes in Global Climate

Thomas R. Armstrong, U.S. Geological Survey, tarmstrong@usgs.gov

The primary goal of the abrupt climate change research element of the Climate Change Science Program (CCSP) is to provide decision-makers and the general public with a better understanding of the potential risks, causes, and ultimate impacts of future abrupt climate changes. This improved understanding will help in developing future climate scenarios and will lead to enhanced response plans to forcing-events that include global warming, sea-level rise, strong storms, floods, and droughts as just a few examples. Additionally, the science information garnered from this assessment will be critical in understanding the linkages between past and present abrupt changes, ecological thresholds, and the consequent short- and long-term ecological responses that may have profound impacts on the state and health of human populations and critical ecosystems worldwide.

Synthesis and Assessment Product (SAP) 3.4 will bring together and report on the current state of scientific information and our understanding of the processes and consequences of abrupt changes in global climate, and on the types of risks related to these events. The report from this effort will be used to build a conceptual framework within which both future research can be developed and related management actions can be addressed, vetted, and ultimately used for better decision-making. Results from the report will lead to a better understanding of the causes, interconnections, and feedbacks related to abrupt climate changes and the physical responses that occur as a result of these events. The report will focus on synthesizing peer-reviewed studies that provide the best available science on abrupt climate changes, and also will compile and discuss the ramifications of studies that report on sudden climate changes and the associated ecological responses to their forcings. This presentation will provide information concerning the scope of the SAP, key issues to be addressed, the scope of the intended audience, the SAP development schedule, the processes for its development, and opportunities for public input and scientific review.

P-DS1.4

National Academies Reports on Radiative Forcings and Climate Change Feedbacks

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Chris Elfring, National Academies Board on Atmospheric Sciences and Climate
Amanda Staudt, National Academies Board on Atmospheric Sciences and Climate
Daniel Jacob, Harvard University, Cambridge, MA
Dennis Hartmann, University of Washington, Seattle, WA

The National Academies produce over 200 reports a year, bringing the best available insights from science and technology to help inform public policy decisions. Two recent National Academies' studies, undertaken upon request from the Climate Change Science Program, have summarized the state of science, informed federal climate-change research agendas, and provided guidance to policy makers.

The first, *Radiative Forcing of Climate Change: Expanding the Concept and Addressing Uncertainties* (2005), focuses on how the energy balance regulating Earth's climate is modified by human and natural perturbations, or "forcings," including greenhouse gases, aerosols, land use, and the amount of energy Earth receives from the Sun. The report supports decisions about future research agendas by identifying critical ways to improve understanding of forcings. In particular, further research is needed to better characterize the vertical and geographical distributions of forcings to account for climate impacts besides temperature in quantifying the relative impacts of forcings and to target critical uncertainties, such as those associated with forcing by aerosols. In addition, the report provides guidance for those who make policy decisions, including a recommendation that they consider potential impacts on climate forcings when developing air pollution regulations and land management strategies.

The second report, *Understanding Climate Change Feedbacks* (2003), examines processes in the climate system known as "feedbacks" that can either amplify or dampen the system's response to forcings. Examples of important feedbacks include (1) those that affect the magnitude of climate change, particularly associated with changes in clouds, water vapor, the atmospheric lapse rate, ice albedo, the carbon cycle, and atmospheric chemistry; (2) those that affect the transient response of climate, mainly involving ocean heat uptake and circulation; and (3) those that affect the pattern of climate change, largely associated with land hydrology and vegetation. A substantial part of the uncertainty in projections of future climates is attributed to inadequate understanding of feedback processes internal to the natural climate system. The report guides the development of future research agendas targeted at improving understanding of these key climate feedback processes, focusing on efforts needed to better observe, understand, and model them.

P-DS1.5

CCSP Synthesis and Assessment Product 4.2: State-of-knowledge of Thresholds of Change that Could Lead to Discontinuities (Sudden Changes) in Ecosystems and Climate-Sensitive Resources

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William Hohenstein, U.S. Department of Agriculture
Bryce Stokes, U.S. Department of Agriculture
Jeff Amthor, U.S. Department of Energy
Susan Herrod-Julius, Environmental Protection Agency
Kenric Osgood, National Oceanographic and Atmospheric Administration
Henry Gholz, National Science Foundation

A primary goal of the Ecosystems research element of the Climate Change Science Program (CCSP) is to enhance understanding of, and the ability to forecast, impacts of future climate change on ecosystems. Reports in the ecological and climate system literature document recent impacts of changing climate conditions on ecosystems, including changes in timing of species life history phenomena; alterations in the distribution of species; changes in spatial extent and distribution of ecosystems and in location of major ecotones; and alterations in ecosystem function or processes. Increasing focus is being placed on the existence and likelihood of threshold-type behaviors that could result in sudden changes in the responses of ecosystems. Such discontinuities in ecosystem behaviors are more difficult to predict, and are likely to result in more profound changes in human societies that depend on ecosystem goods and services. While the possibility of threshold changes in ecosystems are suggested by current ecological theory and models, and are documented in the paleoecological record, they are poorly understood. It is unclear under what circumstances such behaviors will occur in the future in response to climate change, as opposed to more gradual, continuous changes in ecosystems.

Science and Assessment Product 4.2 will address and synthesize the present state of scientific understanding regarding thresholds of change that could lead to discontinuities or sudden changes in ecosystems in response to climate change. The resulting report will develop a conceptual framework within which scientific results regarding sudden changes in ecosystems will be discussed. The report will focus on identifying and synthesizing peer-reviewed studies that provide the best available evidence to help define circumstances that are likely to lead to sudden changes in ecosystems or resources. The report will also synthesize studies that clarify specific difficulties in the ability to identify the likelihood of sudden changes in ecosystems as a consequence of climate change. The poster will provide information on the scope of the assessment to be completed, key issues and questions to be addressed, intended audience, assessment schedule, the process to be followed, and opportunities for public input and scientific review.

P-DS1.6

CCSP Poster on Synthesis and Assessment Product 4.3: The Effects of Climate Change on Agriculture, Biodiversity, Land, and Water Resources

William Hohenstein, Department of Agriculture
Bryce Stokes, Department of Agriculture
Jack Waide, U.S. Geological Survey
Jeff Amthor, Department of Energy
Susan Herrod-Julius, Environmental Protection Agency
Woody Turner, National Aeronautics and Space Administration
Paula Bontempi, National Aeronautics and Space Administration
Ned Cyr, National Oceanographic and Atmospheric Administration
Tom O'Connor, National Oceanographic and Atmospheric Administration
Kenric Osgood, National Oceanographic and Atmospheric Administration
Henry Gholz, National Science Foundation
Phil Taylor, National Science Foundation

The Climate Change Science Program (CCSP) Synthesis and Assessment Product 4.3 will address the effects of climate change on agriculture, land, water resources, and biodiversity. The report will synthesize and evaluate what is presently known about the potential consequences of climate variability and change on major systems within the United States. The systems and selected attributes that will be addressed in this product include: agriculture, forests, freshwater ecosystems, marine ecosystems, species diversity, and at-risk ecosystems (e.g., high latitude or high altitude systems).

Climate variables are linked to specific ecosystem responses through complex webs of interacting processes. Impacts of climate change on ecosystems and their constituent species and processes are complicated by the impacts of numerous human actions, including land use changes that fragment and degrade ecosystems at various spatial scales, pollutants, invasions of non-native species, and resource management and utilization practices.

The report will address a number of issues, including: identifying climate-related stresses facing ecosystems in the United States and understanding how these stresses might change in the future, absent climate change; evaluating current and potential future monitoring systems to better detect ecosystem changes that are caused by climate change; and identifying adaptation options and strategies that could be used to mitigate and ameliorate current and future climate change related stresses. The poster will provide information on the scope of the assessment to be completed, key issues and questions to be addressed, intended audience, assessment schedule, the process to be followed, and opportunities for public input and scientific review.

P-DS1.7

CCSP Synthesis and Assessment Product 4.4: Preliminary Review of Adaptation Options for Climate Sensitive Ecosystems and Resources

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Bryce Stokes, USDA
Bill Hohenstein, USDA
Jack Waide, DOI
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Ed Sheffner, NASA
Kenric Osgood, NOAA
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Climate is one of the dominant factors influencing the distribution and abundance of life on Earth. Changes in climate will interact with other anthropogenic stressors to determine the future condition of biodiversity and ecosystems. Such changes may mean risks of ecosystem disruption, species extinction, and loss of valuable ecosystem services. These risks can be reduced through management activities that facilitate adaptation and increase the resilience of ecological systems to climate change. Product 4.4 will identify and evaluate different adaptation options by describing the relationship between management decisions, ecological outcomes, and supporting scientific information. The assessment will provide information on the potential for adaptation interventions and research to help decision makers reduce the risks of those undesirable ecological outcomes associated with climate change. The poster will provide information on the scope of the assessment, key issues that will be addressed, the intended audience, the schedule for the assessment, the general process that will be followed, and subsequent opportunities for public input and scientific review.

P-DS1.8

CCSP Synthesis and Assessment Product 4.5: Analyses of Effects of Global Change on Energy Production and Consumption

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SAP 4.5 will summarize the current knowledge base about possible effects of global change on energy production and use in the United States. It will survey and assess the available literature, including attention to findings from research about implications of climate variability on energy production and use; identify and consider relevant studies carried out in connection with CCSP, CCTP, and other programs of CCSP agencies (e.g., EIA); and consult stakeholders such as the electric utility and energy industries, environmental non-governmental organizations, and the academic research community to determine what analyses have been conducted and reports have been issued. It is aimed at completion by June 2007.

Although the prospectus for SAP 4.5 has not yet been submitted for public comment and revision, and its scope, questions, and approach may be modified to reflect comments received, the central questions to be addressed by SAP 4.5 are expected to be:

- How might climate change affect energy consumption in the United States?
- How might climate change affect energy production and supply in the United States?
- How might climate change affect various contexts that indirectly shape energy production and consumption in the United States, such as energy technologies, energy institutions, regional economic growth, energy prices, energy security, and environmental emissions?

SAP 4.5 will be prepared and authored by staff from the DOE national laboratories, making every effort to identify and utilize all relevant sources. Under the oversight of a Coordinating Team, chapter authors will utilize professional networks, bibliographic information sources, and stakeholder input to identify relevant knowledge bases, direct and indirect; compile all available data in consultation with other experts in the public sector, the private sector, NGOs, and the academic research community; assess the available knowledge base using established analytic-deliberative practices, also in consultation with other experts; develop a summary of what is known and what is not yet known, along with possible priorities for improving the knowledge base; and produce a summary statement of conclusions as supported by the research evidence, along with an evaluation of levels of confidence represented by each statement. For the information of stakeholders and other interested parties, a web site for SAP 4.5 will contain full information about the assessment and the process, including the Prospectus, information about the authors and workshops, and—as appropriate—draft materials under review, with opportunities for readers to submit comments and questions.

P-DS1.9

CCSP Synthesis and Assessment Product 4.6: Analyses of the Effects of Global Change on Human Health and Welfare and Human Systems

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Anne Grambsch, EPA
John Houghton, DOE
Lawrence Friedl, NASA
Caitlin Simpson, NOAA

The goal of Product 4.6 is to develop an interdisciplinary effort to examine linkages across physical, biological, and human systems in assessing the impacts of environmental change on human health and well being and to inform adaptations in the provision of public health and health care interventions. Health effects associated with global change are wide-ranging and occur via pathways of varying directness, scale and complexity. Timely knowledge of these effects can support the public health infrastructure in devising and implementing strategies to compensate or respond to these effects. This poster will outline the scope of the Product 4.6 Assessment, including key issues to be addressed and the intended audience. The poster will also include a time line for the preparation of Product 4.6 and an overview of the process that will be followed, including opportunities for public and scientific review.

P-DS1.10

CCSP Synthesis and Assessment Product 5.2: Best Practice Approaches for Characterizing, Communicating and Incorporating Scientific Uncertainty in Climate Decision Making

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Uncertainty is ubiquitous in addressing all aspects of the climate problem. To assist the climate research and decision making communities to characterize and deal with uncertainty, M. Granger Morgan[1], together with Hadi Dowlatabadi[2], Max Henrion[3], David Keith[4], Robert Lempert[5] and Thomas Wilbanks[6] are developing a report that will outline available tools and strategies and discuss their strengths and weaknesses. The current draft outline is as follows:

1) Sources and types of uncertainty
2) Characterizing uncertainty
3) Thinking about uncertainty

4) Expert elicitation
5) Analysis of, and with, uncertainty
6) Communicating uncertainty
7) Making decisions in the face of uncertainty

Once the authors have completed a draft it will then be subjected to extensive review by the research community and other interested parties.

[1]Department of Engineering and Public Policy, Carnegie Mellon University; [2]Institute for Resources, Environment and Sustainability, University of British Columbia; [3]Lumina Systems; [4]Department of Chemical and Petroleum Engineering and Department of Economics, University of Calgary; [5]The RAND Corporation; [6]Environmental Science Division, Oak Ridge National Laboratory

P-DS1.11

The National Academies: Informing National Decisions on Climate and Global Change

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The National Academies have been providing independent, objective advice to the nation on issues of science, technology, and medicine for over 140 years. Advice is provided through consensus reports prepared by committees of experts—all whom serve without pay. Members of study committees are selected to ensure that they have an appropriate range of expertise, a balance of perspectives, and are screened for conflicts of interest. Study committees gather information in public meetings but carry out their deliberations and prepare draft reports in private to avoid political, special interest, and sponsor influence. As a final check on the study's quality and objectivity, all reports undergo a rigorous, independent review by external experts.

Recent and ongoing Academies' studies to inform the evolution of the science research agenda in key areas of climate and associated global change include:

- *Abrupt Climate Change: Inevitable Surprises* (2002);
- *Understanding Climate Change Feedbacks* (2003);
- *Decision Making for the Environment: Social and Behavioral Science Research Priorities* (2004);
- *Implementing Climate and Global Change Research: A Review of the U.S. Climate Change Science Program's Final Strategic Plan* (2004);
- *Radiative Forcing of Climate Change: Expanding the Concept and Addressing Uncertainties* (2005);
- Strategic Guidance for NSF's Support of the Atmospheric Sciences (ongoing); and
- Committee to Provide Strategic Advice on the Climate Change Science Program (being organized).

Recent and ongoing Academies' studies to inform national policy and adaptive management decisions related to climate and associated global change include:

- *Making Climate Forecasts Matter* (1999);
- *Climate Change Science: An Analysis of Some Key Questions* (2001);
- *Thinking Strategically: The Appropriate Use of Metrics for the Climate Change Science Program* (2005); and
- Climate Change and U.S. Transportation (ongoing).

Other current or planned Academies' studies related specifically to decision support include:

- Estimating and Communicating Uncertainty in Weather and Climate Forecasts (ongoing);
- Analysis of Global Change Assessments (being organized);
- Extending Observations and Research Results to Practical Applications: A Review of NASA's Approach (being organized);
- Strategies and Methods for Climate-Related Decision Support (in development); and
- Design Issues for the NOAA Sector Applications Research Program (in development).

In addition to these studies, both the Climate Research Committee and the Committee on the Human Dimensions of Global Change convene numerous forums for dialog and facilitate communication on climate and associated global change issues among the U.S. research community, agency leadership, and key international scientific programs.

P-DS1.12

Lessons Learned from Decision Support Processes in Place-based Settings

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Continuing the place-based assessments initiated in conjunction with the first National Assessment of the Potential Consequences of Climate Variability and Change, the Environmental Protection Agency has launched three second-phase projects in the Great Lakes, the Mid- and Upper-Atlantic, and the Gulf Coast. While the initial assessments focused on identifying impacts of climate variability and change, Phase II of the assessments is designed to examine decision processes and develop information and decision tools to support adaptation to those impacts. These assessments are consistent with Goals 4 and 5 of the CCSP Strategic Plan: understanding the sensitivity and adaptability of different natural and managed ecosystems and human systems to climate and related global changes, and exploring the uses and identifying the limits of knowledge to manage risks and opportunities related to climate change.

The regional assessment teams are led by Michigan State University for the Great Lakes; Pennsylvania State University for the Mid- and Upper-Atlantic, and Texas A&M University for the Gulf Coast. Each regional assessment team is taking a different approach to producing decision-relevant information. The Great Lakes study is focusing on developing decision analytic tools to support decisions associated with specific sectors (tourism and agriculture). The Mid-Atlantic study has the dual focus of developing and providing region-wide information via an interactive website and developing location-specific decision support tools. The Gulf Coast is focused on understanding the mechanics of decision processes associated with environmental challenges such as climate change that have significant uncertainties, and the factors that contribute or detract from the use of scientific information in actual decisions. This presentation will focus on the lessons EPA has learned from these assessments about how to produce more effective and relevant scientific information and tools for decision makers. Areas that will be discussed include the ways in which scientific information flows and how it is used by different stakeholders to support decision making, what types of information are needed, what level of confidence decision makers have in various information sources, and how specific tools and information can be developed to address decision makers' needs more effectively. This presentation addresses the CCSP's interest in the type of information that decision makers and other stakeholders need to inform decision making and provides some insight on opportunities for improving the application of currently-available information and priorities for future CCSP research.

P-DS1.13

Meeting Societal Needs: Regional Integrated Assessments in Support of Decision Making

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Over the past seven years the Union of Concerned Scientists (UCS) has worked with independent experts in the global change research community to assess and communicate the projected impacts of climate change across three regions of the U.S.—California, the Great Lakes, and the Gulf Coast. The reports from each of these assessments continue to be used by local, state and regional decision makers in related management and policy initiatives. We attribute the success of these assessments in motivating and supporting climate-related decisions to four factors: (1) credibility, attained both through scientific peer-review and by engaging local scientific and community leaders; (2) regional relevance of assessment focus areas; (3) accessible presentation of the results to non-technical audiences; and (4) wide communication and distribution of the report to the media, the public, civic groups, and public officials. The paper will describe lessons learned from this assessment process, focusing primarily on a recent assessment in California, and the associated public briefings and ongoing outreach activities. The larger lessons drawn from these assessments are how credible scientific analysis combined with concerted efforts to reach the public, resource managers and policy-makers can help meet the evolving needs of decision-makers as they seek to implement appropriate societal responses to climate change through mitigation and adaptation measures. We also make recommendations on how such lessons might best be applied to a reinvigorated effort by the federal government to provide a comprehensive assessment of the effects of global change on the natural environment, human health and welfare, agricultural, and other specified areas, as mandated to be completed on a quadrennial basis by the U.S. Global Change Research Act of 1990.

P-DS1.14

A Synthesis and Outreach Program on Climate Variability and Change Research in the Northeastern U.S. and Eastern Canada

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A new program on: A Synthesis of Climate Change Research in the Northeastern U.S. and Eastern Canada has been initiated in July 2005. The goals of this 2 year program are to (1) summarize the accumulating climate variability and change research on northern forest ecosystems in the region, and (2) make this summary available to policy makers, land and resource managers, stakeholders and the interested public. The program goals will be accomplished in a three-phase process. Phase 1 will involve a survey of end-users (including state and provincial agencies and governments, NGO's, land managers, education organizations, and industry) to assess what type of information would be most useful and relevant, and what format(s) would be most accessible. Phase 2 will involve a scientific synthesis of climate variability and change research in the region, resulting in a peer reviewed paper suitable for a journal such as BioScience or PNAS. This document will include (1) a review of the historical record of climate within the region, (2) environmental indicators of this past climate change, (3) updated climate projections for the region, (4) current research on these issues within the region, (5) ecological implications of this change for the northern forest, and (6) future scientific research needs. Phase 3 will translate this document for the nonscientific community. Results from Phase 3 will be disseminated to the appropriate stakeholders as a Forest Service General Technical Report (GTR), a web site, and fact sheets. This project is unique in that it will (1) update the work done for the New England Regional Assessment, (2) include the northern forest regions of Eastern Canada as well as the northeastern United States, and (3) focus primarily on the northern forest ecosystem.

P-DS2.1

Sources, Characterization, and Communication of Uncertainty in Climate Impacts

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The effects of fossil fuel burning and land use on climate leads to a need for policy decisions regarding energy and development. Unfortunately, climate and its impacts comprise a highly complex system, and as a result, uncertainty in can enter at many points and in many forms. The best decisions require the best possible information, including characterization of the level of uncertainty associated with the "best guess," in either a quantitative or qualitative format. Uncertainty in climate predictions and their impacts can enter in the form of: 1. Natural variability, such as year-to-year variations in the storage of a reservoir for irrigation and hydroelectric use. 2. Incorrect assumptions, e.g. what if population growth slows more rapidly than even the lowest predictions? 3. Qualitative uncertainty, e.g. will agricultural expansion in an undeveloped region be in the form of low-technology smallholdings, or energy- and chemical-intensive industrial agriculture? 4. Known unknowns, such as wars, diseases, extinctions, or technological changes, and 5. Unknown unknowns, such as future events or patterns that do not have present or past analogues. Further complexity results when climate and its impacts result in feedback loops (either positive or negative feedback), as when warming due to greenhouse gases leads to greater energy use for air conditioning, or when land use change results in regional climate change that can affect the viability of agriculture or other land uses. This presentation will cover some proposed approaches to dealing with diverse sources and forms of uncertainty, summarizing the range of possible outcome scenarios and their relative probabilities, and communicating these findings to policymakers and the public in a way that combines accuracy, robustness, clarity, and usefulness.

P-DS2.2

Risk Modeling Using Multiple Probability Distributions for the Climate Sensitivity

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A major challenge for climate policy is the uncertainty in the climate sensitivity, defined as the equilibrium increase of global mean surface temperature in response to an equivalent doubling of CO_2. The IPCC has reiterated in all its assessments the judgment that the climate sensitivity is probably between 1.5 and 4.5ºC, without ever quantifying the probability that it is outside that range. The vagueness of the range has been a long-standing problem for risk modelers, who need a usable probability density function (PDF) for quantitative risk analysis.

Now, however, the problem is no longer that there is no such PDF, but that there are too many. At least six climate sensitivity PDFs have been published recently, which place from 3% to 30% of the distribution over 4.5ºC. Honest appraisal makes it clear that we have today little grounds for aggregating these diverse PDFs or choosing among them; thus policy modelers and their constituencies must begin to work with multiple PDFs, and to grapple with the consequences of such multi-dimensional uncertainty.

In this poster we present a practical way of viewing multiple PDFs and their numerical characteristics, using a simple, spreadsheet-based tool with a database of published climate sensitivity PDFs. Then, using a selection from the database, we show how multiple PDFs can be used in probabilistic risk models to address three different policy-relevant questions: (1) the implied equilibrium temperature of a given level of radiative forcing (in Wm^{-2} or CO_2-equivalent); (2) the implied equilibrium temperature of a specific CO_2 concentration given uncertainty in non- CO_2 forcing; and (3) the implied equilibrium temperature of a specific increase in radiative forcing, given uncertainty in current net radiative forcing.

Although this presentation focuses on examples based on global policy questions, the methods presented are of practical use for a much wider range of climate risk models, as the uncertainty in the climate sensitivity is a major component of uncertainty in all models linking emissions scenarios to impacts. We conclude with an example of how, combined with a simple impact model for potential species extinctions, multiple climate sensitivity PDFs can be used in models at a variety of scales to evaluate the extinction risks of various policy scenarios.

P-DS2.3

Simple Climate-Economy Models: Transparent Tools for Policy Making or Opaque Screen Hiding Methodological Arbitrariness?

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Simple climate-economy models are still being used for climate policy analysis, despite the limitations associated with their lack of regional and process detail. The main argument brought forward in favour of these models is their relative transparency, which should enable researchers to easily interpret the simulation results and adapt the model design to their specific research interests. We investigate to which degree this claim is supported in the case of the DICE model, arguably one of the simplest and most widely used global climate-economy models ever developed. We discuss the use of different welfare metrics and the handling of time discounting, assumptions about the evolution of carbon abatement costs over time, and the calibration of uncertain properties of the climate system. The unsettling conclusion of our reanalysis is that each of these aspects has been treated inadequately or inconsistently in previous studies. The discovered flaws are not only of theoretical interest; some of them do also strongly affect the policy recommendations drawn from the simulation results. This conclusion is particularly disturbing given that DICE has been publicly available for many years, and that this

model has been used and adapted by many researchers. As a consequence of these findings, we call for more caution in the development, application, and modification of simple climate-economy models, and in the interpretation of their results. The combined efforts of original model developers, analysts applying and adopting an existing model, and peer reviewers are required to ensure that the model application is scientifically sound, and that the policy conclusions drawn from a particular model experiment are actually supported by the simulation results.

P-DS3.1

Ensuring Climate Services for the Nation

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Climate services have been defined as the timely production and delivery of useful climate data, information and knowledge to decision makers (NRC, 2001). In this paper, we map the evolution of the idea of climate services and describe the network and infrastructure existing and needed to develop and coordinate such services. Experiences are drawn from the NWS field offices, the State Climatologists, Regional Climate Centers, RISAs, USDA NRCS and Extension services, the NCTP program, the private sector and others. Cases are drawn from, among others, the 1997-1998 ENSO and the extended drought in the Western U.S. and their impacts in different sectors and watersheds. A major goal for effecting "services" is to design a cooperative implementable mechanism for ensuring that climate-related information (across timescales) is developed and provided at national, regional, state and local levels in ways that better inform decision making. While existing "service-type" activities can be identified in many settings, we show that the problem is actually one of crafting effective implementation strategies for cooperation among several entities, highlighting potential synergies or common interests among the different groups. The development of well-structured paths from observations, modeling and research to usable information requires careful (i.e. acceptable and credible) integration of management and decision making groups (private, state, federal etc.), knowledge provision systems, and the implementing agencies and information providers. We assess whether/how these integrated perspectives and information have been used and have value for decision-making among federal, state and local agencies and actors For this presentation we focus on identifying key players, and existing and needed information networks for managing climate-related risks, opportunities and information within which NOAA activities are embedded.

P-DS3.2

SPARC: Science Policy Assessment and Research on Climate

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Each day, in the face of deep uncertainty, millions of decisions are made that respond to and influence the behavior of climate. How does the nation's multibillion dollar investment in climate research affect those decisions? How can the societal value of this scientific investment be enhanced? These are the core organizing questions for Science Policy Assessment and Research on Climate (SPARC) which conducts research and assessments, outreach, and education aimed at helping climate science policies better support climate-related decision making in the face of fundamental and often irreducible uncertainties. SPARC's current research focuses on science policy decision making with respect to the carbon cycle, water, extreme events and ecosystems. SPARC is a joint project of the University of Colorado's Center for Science and Policy Technology Research and the Arizona State University's Consortium for Science, Policy, & Outcomes, sponsored by National Science Foundation (NSF) under its program on Decision Making Under Uncertainty. http://sciencepolicy.colorado.edu/sparc/

P-DS3.3

The Multiple Audiences Problem in Constructing Effective Syntheses of Scientific Information for Purposes of Influencing Public Policy

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Kerk F. Kee, San Diego State University

Public policy on topics of scientific research is influenced by communication from a number of sources: the scientific community, corporate and media interests, governmental agencies, nongovernmental research and policy organizations, the activist community, and by perceptions of the beliefs of the "silent public." The information needs of these groups differ and require the construction of different yet consonant messages for communication to be effective.

While policymakers themselves may seem to be the prime target for messages describing scientific findings that have policy implications, we argue that such direct contact is generally ineffective. We suggest instead that messages should be constructed to reach audiences who are likely to be successful in making the topic a salient one to the policymakers they are able to influence.

Constructing variations to messages requires two steps. First, the scientific community needs consensus about findings on topics where it believes changes of policy are most pressing. Second, the leaders of this effort need to identify those individuals and groups who are most able to succeed in influencing the largest number of policymakers, identify the information needs of such opinion leaders, and construct variations on the consensus synthesis to meet those differing information needs.

This presentation analyzes the problem of multiple audiences for scientific information, suggests how information needs might vary among these multiple audiences, and offers strategies for constructing variations on messages to meet differing information needs. We will draw from recent work on how audiences use specialized information and on the nature of news consumption in the U.S. in constructing our recommendations.

P-DS3.4

An Analysis of Some Problems in the Transmission and Use of Climate Research by Public Policy Decision Makers and Some Suggestions for Improving the Process Using Currently Available Tools

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Christopher Horner, Competitive Enterprise Institute
Marlo Lewis, Competitive Enterprise Institute
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An enormous amount of high-quality scientific research on a wide variety of topics relevant to the public debate over climate policy has been and is being done. However, the usefulness of that research to the policy-making community has often been limited and compromised by a number of factors involved in the translation of complex, technical research into the policy vocabulary of the political arena. This presentation will consider and analyze several notable instances in which the needs of policy makers have been poorly served by climate science research, not because of the research itself, but by distortions and misapprehensions introduced in this translation process. Several suggestions for improving the process and minimizing these distortions and misapprehensions by using tools developed over many decades in the context of other but similar research/public policy/political decision-making interfaces will be made.

P-DS3.5

Development and Gap Analysis of Climate Change Educational Resources Collection for K-12

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In the minds of many citizens in the United States, the topic of "climate change" is clouded with confusion. While there is strong consensus within the climate research community about the general range and causes of natural variations in the climate system, as well the role of human activities on the Earth's climate system, these complex topics are poorly understood by many decision-makers, teachers, the general public, and the decision-makers of the future: science students. While the Climate Change Science Program's Strategic plan called for the development of materials to help these audiences understand the basics of climate processes and dynamics, to date no such materials for a general audience have been developed, tested or disseminated. One recent effort to communicate the basics of climate change and variability may hold potential for helping CCSP meet its communication goals. The Climate Change Collection (http://serc.carleton.edu/climatechange/) developed as a pilot project for the Digital Library for Earth System Education (DLESE Climate Change Collection, NSF Award Number 0435645) is a high-quality, annotated thematic collection of 40 seminal digital resources that were identified and annotated by a review team of science experts and educators, who examined digital resources for scientific accuracy, currency and usefulness to science educators. An experiment in digital science education collection development, the effort brought together a community of experts through an interdisciplinary review board supported by an extended network of climate scientists and educational researchers, developers, and practitioners. This work contributed to the broad DLESE collection in an exceedingly important area of the Earth sciences, while producing and refining a protocol for collection-building that can be transferred to other Earth science domains. Based on the findings of the pilot project, a further gap analysis is needed along with new products/curricular products to facilitate climate education in the K-12 classroom. Time will be given to discussions and potential collaborations.

P-DS3.6

Documenting Glacier Change and Landscape Evolution: An Alaskan Example of Providing Scientific Information to Support Decision Making and Outreach and Education

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This abstract summarizes experiences in providing U.S. National Park Service (NPS) decision makers and outreach personnel with scientific information about the impacts of climate variability within specific NPS units. Glaciers are Earth's largest freshwater reservoir, a sensitive indicator of changing climate, and an important component of many subpolar ecosystems. They also annually attracts hundreds of thousands of visitors to Glacier Bay National Park (GLBA), Kenai Fjord National Park (KEFJ), and more than a dozen other glacier-hosting NPS units. Therefore, NPS resource managers have a strong and immediate interest in understanding how their glacier resources and associated ecosystems have changed, are changing, and will change in response to climate variability. Consequently, unequivocal information that provides insights and answers into this response is critical for policy- and decision-making and for adaptive management and planning.

For GLBA and KEFJ, NPS resource managers needed information that: 1) Assessed the post-Little-Ice-Age behavior of glaciers; 2) Developed easy-to-understand visual products to convey the results of these assessments; 3) Documented vegetative succession in newly ice-free areas; and 4) Provided information about past and present rates of change that could serve as a basis for predicting future changes.

One approach employed to respond to this need was photographic documentation of long-term change. Beginning in 2002, Park locations which had been photographed in the late-19th- and early-20th-centuries were revisited. Using historical photographs to identify the exact locations from which they were made, more than 175 sites have been examined. At each, the field of view shown in the historical photograph is duplicated. Then, differences between the modern and historic images are quantitatively and qualitatively assessed. For GLBA, this results in a fiord by fiord history of glacier change and landscape evolution, and a visual documentation of more than a century of change. Resulting data are also used to produce GIS coverage for inclusion in a GLBA-wide management GIS. Additionally, visualizations are shared with NPS Rangers who provide visitors with information about the Park's changing natural environment. A similar assessment is underway for KEFJ.

This cooperation with NPS resource managers and outreach personnel is an excellent example of how information developed through scientific research on climate variability and change is serving NPS customer needs on a number of levels, ranging from providing quantitative information to support resource managers in their decision making, to providing site-specific, unambiguous visual documentation to be shared with the public.

P-DS4.1

Robust Adaptation Decisions amid Climate Change Uncertainties

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Mike Hulme, Tyndall Centre for Climate Change Research and University of East Anglia, UK

This presentation deals with the sensitivity of water supply decisions to various uncertainties associated with climate change (e.g., emissions of greenhouse gases, climate sensitivity, global climate models, and regional climate models). The setting is in the East of England, in the UK, the driest region in the country where climate change could exacerbate drought-like conditions.

UK water companies have to plan for the next 25 years and decide what actions they will take in order to maintain security of supply. They currently take into account climate change by using climate change scenarios produced by the UK Climate Impacts Programme (UKCIP02). Our approach tries to quantify a much larger set of uncertainties than those included in UKCIP02 in the assessment of future climate. We are then able to determine the sensitivity of water adaptation decisions to these uncertainties.

Our role in the decision-support process has not been as purely a "user" or a "producer" of climate information. Our role could be better described as an observer or facilitator in the interface between "user" and "producer." We have been "producers" of climate information because we have used publicly available climate data to quantify uncertainties in climate change scenarios. This has been done using a combination of a simple climate model and various global and regional climate models. We also interacted with numerous "users" to elicit what adaptation options they were considering.

The presentation will introduce a number of topics such as the type of information decision makers want; use of scientific information (in particular models and their results) to support decision-making; participatory approaches; communicating uncertainty; and methods and metrics to evaluate outcomes. In order to support their decision-making, water companies in the UK would prefer to use probabilistic climate projections rather than scenarios. We have noted that models are important for incorporating climate change into water resources planning. The industry has attempted to follow a simple approach, but because of the complexity introduced by climate change it is particularly important to manage and communicate uncertainties associated with climate change. We have also found that participatory approaches are crucial for the users to trust the information from the producers and for the researchers to elicit adaptation strategies from the users. We evaluated adaptation strategies using criteria based on robustness, i.e., decisions that are insensitive to uncertainties.

P-DS4.2

Decision Systems Research and Tool Development at the IRI

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We report progress in the development or enhancement of decision tools and decision strategies that account for climate risk. Our experiences to date have been focused on tools for climate risk management at seasonal timescales, that is, incorporating climate forecasts for the upcoming several months, and subsequent monitoring of the evolution of the climate over those months. The experiences are gained through collaboration with partners and stakeholders in many places.

Applications of quantitative decision tools that incorporate seasonal climate information typically focus on either (a) translation into impacts and information that is directly relevant to management, (b) understanding and modeling decision responses and assessing the resulting benefits of alternate decision-making strategies, and (c) fostering and guiding decision responses.

Tailoring climate information ((a) above) can involve linking climate information at a high spatial and temporal resolution into dynamic, process-oriented models of the impacts of interest. We provide such examples in monitoring and predicting crop production, and spatially distributed hydrological variables. For such examples, downscaled daily weather series are often needed, and examples of approaches are given. More direct statistical approaches are also possible for prediction of impact variables. Examples include methods for predicting malaria risk, patterns of remotely sensed vegetation indices, and stream-flow.

Decision models with flexible user interfaces that facilitate "what-if" analysis of outcomes of decision alternatives can be used both to explore potential benefits, and also as decision support tools that communicate opportunities to stakeholders. We present a modeling analysis of the use of forecasts for rainfed crop management in Kenya. Another example that has been explored is a model-based analysis of management of a multiple use reservoir system in the Philippines, which in particular illustrates expected increases in hydroelectric power generation. A windows-based software tool has been developed for exploration of reservoir management with and without seasonal forecasts of expected inflow distributions. Such tools are one piece in a suite of approaches to fostering and guiding response strategies. Other pieces are being explored to contribute to knowledge on how to achieve the most effective uptake of new climate-related information in decision-making, including approaches to ensuring tools best meet the needs of targeted users, and alternative ways to communicate opportunities for improvements in decision-making practice (for example, insurance schemes, games for learning).

P-DS4.3

Applying Climate Variability/Change Information for Early Warning and Response Decision-Making: Lessons Learned from the Conflict Early Warning and Response Mechanism (CEWARN)

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The vulnerability of coupled human-environment systems is one of the central elements of sustainability research whose object requires improved dialogue between sciences and decision-making (Turner et. al, 2003b). African systems are particularly vulnerable to climate variability and related environmental processes. Overall rises in temperature are expected to reach double the global rise in central Africa, with increased risk of extreme droughts, floods and outbreaks of disease in the rest of Africa. However, just as technological progress and human activity have contributed to this problem, it is also within our means to develop, improve, and disseminate structured information for use in decision-making and policy formulation.

It is evident that earth science-based information is needed by local and national resource managers to make environmentally and economically sound decisions. However, human-environment systems are "predicated on synergy between the human and bio physical processes operating at different spatiotemporal (as well as functional) scales" (Turner et. al. 2003b). One basic challenge in providing decision-makers and stakeholders with relevant information is therefore geostatistical: how to correlate structural data (e.g., rural sub-national development indicators in the Horn of Africa for a specific polygon), with behavioral boundary data (e.g., violent behavior such as pastoral conflict), with raster data of various resolutions (e.g., local climatic/rainfall/ temperature/vegetation variations) in an integrated—yet necessarily asynchronous—decision-oriented framework.

The purpose of this presentation is to explain how the Conflict Early Warning and Response Mechanism (CEWARN) integrates climate information to address societal and scientific challenges within a client-based, decision-oriented framework. The Intergovernmental Authority on Development (IGAD) in East Africa directs the CEWARN project and as a (non-scientific) senior consultant and developer of CEWARN, I seek to integrate information on environmental/climate variability/change and related processes with behavioral/social variability/change to inform early response decision-making by Member States. For example, the project draws on observations and seasonal-to-inter annual precipitation forecasts to enhance environment-conflict analysis for early warning. The framework thus combines geophysical time series data with geospatial social/behavioral time series data using geographic information systems and baseline analyses. This presentation explores CEWARN's application of information developed through science and technology research to support decision making in the areas of water and conflict prevention. The presentation will suggest priorities for future research in view of information science potential and CEWARN's information needs for decision-making.

P-DS4.4

Climate Change Science for Development

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The USAID Global Climate Change Program funds environmental programs that reduce growth in greenhouse gas emissions while promoting sustainable agriculture, forest conservation, biodiversity, and other development goals. These projects rely on up-to-date scientific information and specific scientific deliverables that address both the potential for developing countries to mitigate climate change and the effects of climate change on developing countries.

USAID has adopted a "multiple benefits" approach to addressing climate change, in which projects are designed to help mitigate or adapt to climate change, while advancing development goals such as improved natural resource management, biodiversity conservation, food security, and improved health and nutrition. These same projects can also help reduce the vulnerability of ecosystems to climate change. For instance, reduced tillage and contour planting by farmers increases soil organic carbon sequestration and therefore enhances soil fertility, which helps increase food security in developing countries.

In order to identify the best opportunities for concurrently addressing climate change and sustainable development through the multiple benefits approach, USAID requires science evaluating the effects of various mitigation strategies and information on sectors and regions most vulnerable to climate change. Informed decisions are essential to climate change mitigation and adaptation as well as sustainable natural resource management and economic development, all of which are key priorities for USAID.

P-FP 1.1

The Multiple Roles of Satellite Data in Livelihood Based Famine Early Warning for Decision Makers

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For nearly two decades, the United States' Agency for International Development's Famine Early Warning Systems Network (FEWS NET) has advised local, national and international partners on African food security issues. During the past four years, this program has expanded to two more regions and will soon be available to those countries worldwide who request the program. A founding partner of the program, NASA has contributed real time satellite data for rangeland health, cropped area and rainfall estimation. FEWS NET has implemented a new approach to quantifying food security that incorporates food prices, wealth ranking and levels of vulnerability with agricultural production information in a decision support system. The livelihoods-based food security early warning system is an analytical framework designed to help decision-makers understand the effects of different "shocks" on household-level livelihood options and focuses on areas that are highly sensitive to biophysical hazards such as drought. The livelihoods analysis is used in a broader early warning system that organizes information about people living in rural and urban households and, when necessary, connects it to decision makers providing different types of assistance in support of their lives. The quantitative representation of the different food and cash income options available to different types of households in a particular geographic area is typically presented in a baseline report and a food economy spreadsheet designed to facilitate food security outcome analysis. Satellite data can be used in each level of the food security analysis once the baseline study on food economy has been conducted. Satellite derived products contribute to estimates of the area of food crops planted in a particular year (LandSAT data), monitoring of crop health throughout the season (TRMM), estimates of the percent of normal production harvested (MODIS, AVHRR), development of rangeland depletion curves (MODIS, TRMM), and inputs to models projecting food price changes over the coming year (AVHRR, SPOT Vegetation). As a recently funded NASA application, we are currently developing short-term (1-3 month) projections of these indicators to improve early warning of food insecurity for decision and policy makers worldwide.

P-FP 1.2

Global Agricultural Monitoring: Science Information to Inform Decision Making

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The Global Agriculture Monitoring (GLAM) Project aims to enhance the agricultural monitoring and crop production estimation capabilities of the USDA Foreign Agricultural Service (USDA/FAS) using NASA's moderate resolution satellite data. The project is a collaboration between NASA/GSFC, USDA/FAS, and University of Maryland College Park (UMD) Department of Geography, in the framework of a joint NASA/USDA MOU to foster increased cooperation between the two agencies.

The primary mission of the FAS is to provide agricultural information for global food security through delivery of objective, timely and regular assessments of global agricultural production outlook and the conditions affecting it. To meet its objectives, the FAS uses satellite data and products to monitor agriculture and to locate and keep track of the climatic factors that impair agricultural productivity such as short and long-term droughts, floods and persistent snow cover. These data are used to augment regional field-based reporting and help in the decision-making process.

To monitor crop conditions, the FAS analysts are provided with multiple remotely sensed products from moderate resolution sensors for target agricultural regions worldwide. This includes providing USDA crop analysts with a sophisticated web interface for analyzing MODIS temporal composites of vegetation index (VI) data, at 250-meter resolution. The web interface provides analysis tools which allow the crop analysts to drill down to the pixel level of detail. Using these data and tools, FAS analysts track the evolution of the growing season and make inter-annual comparisons of season dynamics between individual years as well as relative to reference long-term mean conditions. These comparisons yield anomaly images and plots that highlight regions that are less productive relative to previous years due for example to drought and heat stress as well as regions that experienced favorable climatic conditions and thus are more productive. For instance, this year eastern Africa experienced a severe drought leaving millions in need of food aid. Using the VI time series and web analysis tools FAS analysts tracked this drought and its effects on agricultural lands forewarning the appropriate decision makers of the crisis. For near real time assessment and evaluation of disaster events such as floods FAS analysts have access to daily global data through the MODIS Rapid Response system which delivers data within 2-4 hours of satellite acquisition.

Although still in its developmental stages, GLAM has proved to be a success, improving FAS' ability to monitor global crop production and its response to climate. The extensive web accessible DBMS, provides a substantial opportunity for a range of applications requiring frequent global moderate resolution data such as the analysis of trends, assessment of the severity of drought conditions and serving as drought early warning system.

P-FP1.3

An Agricultural Information System Based on Satellite Remote Sensing Data for Decision Making

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Monitoring global agricultural crop conditions during the growing season and estimating potential seasonal production are critically important for market development of U.S. agricultural products and for global food security. The Goddard Space Flight Center Earth Sciences Data and Information Services Center (GES DISC) has developed an Agricultural Information System (AIS), based on the GES DISC Interactive Online Visualization and Analysis Infrastructure (Giovanni-Ag), which can operationally provide satellite remote sensing data products (e.g., rainfall) and analysis services. Currently available data include NASA satellite precipitation and other gauge analyses products. Comparison of the 0.25 degree 3-hourly Multi-satellite Precipitation Analysis (MPA) product with limited gauge analysis has shown that the MPA can complement some currently available precipitation products, such as the Air Force Weather Agency (AFWA) precipitation analyses, to provide more accurate rainfall information, especially in remote or sparsely gauged areas. The USDA currently uses AFWA data for operational crop production forecasting. The AIS will enable the remote, interoperable access to distributed data, by using the GrADS-Data Server (GDS) and by being compliant with Open Geospatial Consortium (OGC) standards. AIS outputs are currently being integrated into existing operational decision support systems for global crop monitoring, such as those of the USDA Foreign Agricultural Service and the U.N. World Food Program.

P-FP1.4

Integrating Remote Sensing and Other Products into the Decision Support Systems of the United Nations World Food Programme

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This presentation will describe our collaborative work with the World Food Programme of the United Nations, including web-based information services and tools to assess global and regional water related issues, such as, floods and droughts.

Set-up in 1963, the World Food Programme (WFP) is the United Nations frontline agency in the fight against global hunger. WFP depends on donors worldwide. The United States of America has been the largest donor. Natural disasters, such as, floods and droughts, occur every year in third world countries and often require emergency food aid. Moving large quantities of foods is not an easy task. Time and planning are required. Accurate and timely environmental information will facilitate decision-making and food distribution and maximize the use of contributions.

Few observational data are available for disaster monitoring in remote and poor countries. Satellite observations provide a unique way in providing such data from space. The first author and Dr. Lenard Milich of WFP have been collaborating for the past three years on ways to integrate NASA Tropical Rainfall Measuring Mission (TRMM) data into forward planning exercises for establishing geographic areas (e.g., sub-equatorial Africa, Indonesia, and North Korea) in need of food assistance. However, several issues still remain, such as, expertise and significant resources required for data access and analysis, uncertainties in rainfall estimates, etc.

Our current and future activities will focus on the removal of these roadblocks by enhancing our existing tools for global water and disaster management activities. In particular, the tools will allow to: 1) Monitor global precipitation; 2) Reveal local and regional rainfall surplus/deficit; 3) Reveal uncertainties in near-real-time and climatological/baseline products to better estimate rainfall for flood/drought monitoring and anomalies; 4) Derive climatological information for coastal zones; 5) Derive ENSO rainfall products to understand changes during ENSO events; 6) Use global image viewers for accessing geostationary satellite and NASA MODIS imagery to assess flooding/drought ground conditions; and 7) Prepare presentations for potential donors.

These tools will not only benefit the WFP decision-making activities, but also other local agencies and the general public. All data and services are web-based to minimize the cost for accessing and maximize the use of global rainfall data products.

P-FP1.5

Climate Constraints, Water Limitation and Global Food Security

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In view of the rapid world population increase and the declining stock of natural resources, climate variability and change raised serious concerns about water availability and future capacity of world food production. There are two climate aspects related to water limitations and global food security: current and future climate constraints. Estimates showed that since the 1970s, world dry areas have increased 2.5 times; summer dryness in the interior of the continents and regional drought intensity and frequency is on a rise; in many developed countries climate limitations led to agricultural production leveling off. Additional constraints have been produced by a human-induced large-scale land cover/land use changes (conversion of natural steppe vegetation into agricultural fields, excessive withdrawal of surface water for irrigation, desertification, deforestation, siltation of irrigated lands, pasture overgrazing) which led to water limitation and restrains in agricultural production. A growing public concerns is that human-induced climate changes (temperature increase, reduction of snow and ice cover, etc.) will lead to changes in weather extremes, especially such damaging for agriculture natural disasters as droughts. Even present observations show that in some areas frequencies of environmental disasters is gradually increasing along with the global temperature rise. This presentation will address climate constraints in relation to water limitation with the corresponding consequences for agriculture and global food security issues. It will also discuss such adverse natural disaster as drought which affects severely water resource and agricultural production. Even under current climate conditions drought is known to affect main agricultural areas and highly populated regions of the developing countries. According to future climate scenarios, drought frequencies and intensity is expected to increase progressively with climate warming. This will have wide-reaching effects on availability of food and on the number of poor and undernourished people. The results of this presentation will be based on analysis of long time series of satellite and in situ data.

P-FP2.1

A Prototype, Scenario-Based, Decision Support System for Integrating Food Security and Ecosystem Management in Jamaica

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The development of decision support systems to assist decision-makers and stakeholders in the science-policy-practice dialogue is one of the primary research objectives of the international research project "Global Environmental Change and Food Systems (GECAFS). These decision tools support a fundamental GECAFS goal to determine strategies that create adaptive, food-secure and environmentally-resilient systems that successfully cope with the impacts of global environmental change. In this respect, food security is reflected in a variety of multi-disciplinary concepts including, food utilization (nutritional value, social value, food safety), food access (affordability, allocation, preference) and food availability (production, distribution, exchange). In constructing initial decision support methodologies and tools, researchers have combined aspects of scenario analysis and decision support modeling.

Scenario analysis is a powerful way to think about uncertainty and risk. The methodology assists teams in analyzing past and present trends, detailing possible future developments, and using the insight they gain to explore potential actions designed to improve the current situation. The scenario analysis approach has been shown useful in a variety of contexts, including economic strategy, business development, and environmental management.

The Questions and Decisions ™ (QnD™) screening model system was created to provide an effective and efficient, open-source, decision tool. QnD incorporates ecosystem, management, economics and socio-political issues into a user-friendly model/scenario framework. An initial decision support system (QnD:Jamaica) was created to explore the spatially explicit (parish-level) food, economic and population dynamics of rural and urban populations. QnD's object-oriented design structure allows iterative development of model components that can be easily changed as group learning occurs.

This paper describes how the QnD:Jamaica model was used with different global change scenarios to provide interactive future worlds for participants to explore potential policy actions. Initial scenario results show how the food security of various rural and urban populations can vary over time and space with respect to climatic and economic changes. At local-scales, adaptation options are limited for most resource-poor populations. This vulnerability highlights the need for systematic policy options that integrate food systems, economic and natural resource management.

P-FP2.2

Climate Change Impact on Food Security and Policy Adaptations: A Synthesis from Selected African Countries

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Greenhouse gas induced climatic change is portended to worsen climatic conditions in many developing countries. Agriculture, a critical part of the ecosystem, is particularly susceptible to climate change raising concerns about food security in developing countries. However, policy adaptations to the projected climate change can be critical in mitigating some of the adverse implications of climate change. Implementing adaptations would require a comparative assessment of the effectiveness of alternative adaptations across an array of agroecological conditions. This study considers climate change impact on agriculture sectors in Mali, Senegal, Uganda, and Kenya and presents an assessment methodology and results comparing effectiveness of alternative adaptations. A particular focus of this study is development of policy indicators relevant to decision makers' needs in developing countries and international donor community.

Little is known about potential of mitigative adaptations to climate change in developing countries. As the U.S. is a key player in the international donor community, the information in the presentation is relevant to U.S. decision makers regarding how climate change may impact developing countries and future food aid needs as well as future political instability. The presentation would contribute to priority settings for future CCSP research as the information generated from the study is an integral part of the decision over whether to mitigate greenhouse gas emissions and in the international debate over burden sharing.

The authors are producers of climate impact information playing a role in U.S. and IPCC processes.

P-FP3.1

Linking Seasonal Climate Forecasts with Crop Simulation to Optimize Maize Management

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Advance information about climatic conditions for the upcoming growing season provides an opportunity to improve agricultural risk management and to optimize management practices. Empirical or GCM-based seasonal forecasts linked with crop simulation models provide a means of translating climate forecasts into agricultural production terms, and of assessing the production and economic outcomes of management alternatives. We used a stochastic weather model to disaggregate monthly rainfall predictions into synthetic daily realizations as input into crop simulation models to predict field-scale maize yields at sites in southern Kenya and southern Zambia. The integrated climate-crop modeling predicted a significant portion of final yields well in advance of the normal planting dates. Potential value of a forecast system is established from expected income in response to management optimized for each year's forecast, minus expected response to management optimized for observed climatology, given current cost and price expectations. To estimate the potential value of forecasts for a set of maize management decisions, we identified management optimized for all years and for each year's yields predicted with hindcast rainfall, then applied the optimal management to yields simulated with observed rainfall. In Kenya, analyses of management responses focused on N fertilizer rates and planting density. Yield response to N, averaged across years and in many individual years, fit a nonlinear Mitscherlich function quite well. In those cases, we identified optimal fertilizer rates based on analytical solution of the Mitscherlich function plugged into an enterprise budget to estimate gross margins. Where the Mitscherlich function did not approximate simulated response to fertilizer, we selected the discrete fertilizer level that gave the highest gross margins. In Zambia, we considered cultivar, N fertilizer, planting density and conventional vs. conservation tillage decisions and applied the same discrete gross margin maximization procedure, but without first fitting to the nonlinear production function. The results indicate that modest increases in average farmer income can be obtained by using available seasonal climate forecasts. We anticipate that improvements in methods for translating seasonal forecasts into local crop impacts, and consideration of a broader range of farm-level decisions will increase the potential value. However, there remain several challenges to achieving that potential.

P-FP3.2

Effects of Climate Variability on Irrigation Water Use in the Southeastern United States

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Climate plays a key role in agricultural production in the southeastern United States. The goal of this study was to examine the effects of changes in El Niño-Southern Oscillation (ENSO) phases on irrigation water consumption for peanut production. Annual irrigation water use and the frequencies of irrigation applications were simulated using the CSM-CROPGRO-Peanut model for irrigated peanuts for several counties in Georgia, Florida and Alabama. These simulations were based on long-term historical weather data, different planting dates, and local soil types. Results showed that average annual irrigation amounts and number of irrigation events decreased with delayed planting. The reduction in irrigation water use was more pronounced for El Niño when compared to either the La Niña or neutral phase.

P-FP3.3

Impact of Climate Information in Reducing Farm Risk by Selecting Crop Insurance Programs

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Predictability of seasonal climate variability associated with El Niño Southern Oscillation (ENSO) suggests a potential to reduce farm risk by selecting crop insurance products with the purpose of increasing or maintaining farm income stability. A hypothetical 50% peanuts-50% cotton, non-irrigated, 40 ha (100-acre) north Florida farm was used to study the interactions of different crop insurance products with ENSO-based climate information and relative levels of risk of aversion under uncertain conditions of climate and prices. Crop yields simulated by the DSSAT suite of crop models using multiyear weather data combined with historical series of prices were used to generate long series of stochastic income distributions in a whole farm model

portfolio. The farm model optimized planting dates and simulated uncertain net incomes for 50 alternative crop insurance combinations for different levels of relative risk aversion under different planning horizons. Results suggested that net incomes are greater and more stable for low risk averse farmers when catastrophic (CAT) insurance for cotton and 70 or 75 actual production history (APH) for peanuts are selected in all ENSO phases. For high risk averse farmers the best strategy depends on the ENSO phase: a) 70% crop revenue coverage (CRC) or CAT for cotton and 65% APH for peanuts during EL Niño years; b) CAT for cotton and 65, 70, or 75 APH for peanuts during Neutral years; and c) 65, 70 APH, or CAT for cotton and 70% APH during peanuts for La Niña years are selected. Optimal planting dates varied for all ENSO phases, risk aversion levels, and selected crop insurance products.

P-FP3.4

A Climate-based Tool for Agricultural Nitrogen Management Decisions

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Decisions related to the application of nitrogen on agricultural lands have both economic (crop yield and fertilizer expenses) and environmental (water quality issues related to nitrogen leaching) consequences. These decisions rely heavily on both real-time and recent historical climate information. The newly developed Precision Nitrogen Management (PNM) model links a soil nitrogen (N) dynamics model and a maize nitrogen uptake/growth and yield model with climate information from the NOAA Regional Climate Center Applied Climate Information System (ACIS).

A website provides a user-friendly input and output format for the model. It is intended specifically for crop consultants, growers and any other users who are interested in obtaining sidedress N recommendations for a maize crop. Users are prompted for information related to soil type, cultivar, and previous nitrogen inputs. These are necessary inputs to the nitrogen and crop model. A user-specified zip code allows the ACIS metadata to be queried for the nearest weather observation site. This allows access to the high quality ACIS climate data that are need by PNM model.

Based on recent climate conditions, the PNM model returns a recommended nitrogen application rate to the user via the web. This recommendation optimizes yield and generally specifies an application rate below that which is conventionally used since current sidedress N rate recommendations in New York State do not consider early season climate or early season crop N demand, and growers tend to fertilize for the wettest years. In most years, this results in a reduction in farm expenses and minimizes nitrogen runoff to water bodies.

P-FP4.1

Applications of Climate Information to Agriculture in the Southeast USA: A Perspective from Agricultural Extension Services

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The Land Grant University System (LGSU) has a three-fold mission—teaching, research, and extension. Through Federal legislation, Agricultural Experiment Stations were established in 1887 and the Cooperative Extension Service was established in 1914 specifically to disseminate information produced by research at the experiment stations.

Thus, the LGSU has a long history of linking research with technology users through the extension system.

Extension has two principal components—faculty level Specialists and County Agents. The Extension Specialists are generally co-located with research faculty and in most cases themselves have a partial appointment in research. The County Agents are based in county offices and are often paid in part or full by the county or counties they serve. County Agents have close links with stakeholders and decision makers and the Extension Specialists work with the County Agents to make sure that they have the latest information in their area of specialization.

The Extension Services of Florida, Georgia, and Alabama have been working with the Southeast Climate Consortium (SECC), one of the Regional Integrated Science Assessment centers funded by NOAA, in order to develop information and communication means to deliver climate information to farmers to assist them in making on-farm decisions. The SECC includes both land grant and non-land grant universities, which allows them to combine specialists in climate sciences with those in agriculture and extension. Moreover, SECC researchers from both land grant and non-land grant universities have worked closely with the Extension Services from the beginning of their efforts in order to better understand the needs of agriculture and natural resource sectors for climate-related information. The SECC launched AgClimate, a prototype interactive web site to help County Agents and farmers better evaluate the vulnerability of agriculture to climate variability. County agents and other Extension Specialists have provided inputs and feedback along all stages of AgClimate development.

To date, the Extension Services of these states have not had Extension Specialists for climate, so the SECC hired three Climate Extension Specialists to work with other researchers, Extension Specialists, County Agents, and farmers. In recognition of the great potential value of climate information to the management of climate related risks in agriculture, the Extension Services of Florida have requested a state-funded position for climate. Ultimately, the Extension Services plans to house and manage AgClimate as an operational component of its program. Implications of climate information and management of on-farm risks will be discussed.

P-FP4.2

The Pileus Project: Climate Science in Support of Decision Making

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The Pileus Project at Michigan State University is developing Web-based information and decision support tools for the agricultural and tourism sectors in Michigan. These tools explicitly incorporate historical climate variability and potential future climate change. The agricultural applications are directed primarily at the tart cherry and grain quality industries, but spin-offs to other industries are possible. Both applications cover several stages in the supply/value chain beginning with the farm. The tart cherry application also considers globalization issues that are potentially impacted by climate change.

A key contribution of this project is to identify, in appropriate detail, the information needed in decision making that is influenced by climate and then to work through the implications for the tool development. To accomplish this, the Pileus Project team has interacted closely with potential users and groups that may be impacted by climate variability and change. The decision support models for agricultural applications required building and adapting biological models with daily time steps that capture the impact of weather on plant growth, including susceptibility to weather-based losses such as frost and to conditions that induce plant diseases. Many of the impacts of weather on biological processes are very dependent upon weather sequences (e.g., several unusually warm days in late winter/early spring followed by frost which kills emerging cherry buds or drought conditions which increase susceptibility to stressors in the following year). Therefore, specific time-based information is needed to analyze the impact of changing climate on biological processes. The biological model output, in turn, is an input into economics models.

The tart cherry sector has been conditioned to think carefully about climate variability change and about managing risk because of the sensitivity of their industry to weather and climate. A key focus is on decisions that have impacts 10 to 40 years into the future such as orchard replant decisions, schemes for longer-term financial risk management, and greater flexibility and finding ways to put an economic value on that flexibility.

P-FP4.3

Farmer Climate Risk Management: Insights into Climate Change Adaptation Capacity

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Consensus is emerging in the scientific community that climate change is likely to result in an increase in weather extremes. Farmers, who are highly sensitive to climate extremes, present an opportunity to investigate decision making related to managing climate risk, providing insights into managing uncertainty associated with future climate change. Through surveys, interviews and focus groups with farmers in Eastern New York State, we are studying climate risk management with two aims: first to "map" mental models of frequency distributions of important extreme events of Northeast farmers, and second, to assess farming system resilience to climate extremes among this set of farmers, which includes small dairy, fruit, and vegetable growers. Products of this work will include improved decision support materials in the context of climate risk associated with climate extremes.

P-EC1.1

Influence of Climate Variability on Regional Vegetation and Water Cycle over the East Coast of the United States

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The El Niño/Southern Oscillation (ENSO) has shown its impact on numerous land, ocean and climatic parameters in different parts of the world. The present paper discusses the impact of ENSO on regional vegetation and hydrology over the US East Coast. The Normalized Difference Vegetation Index (NDVI) derived from the AVHRR has been found to decrease 7-10% over the East Coast region during the El Niño years (1982-83, 1987, 1992, and 1994), which is supported by the decrease of evapotranspiration at the same period. During the last two decades, the general trend of normalized NDVI over the US East Coast region has been increased at the rate of 3.72%/decade, while the evapotranspiration has been decreased at a rate of 0.479 mm/decade. At the same time, the regional water cycle is found enhanced, and the ENSO has important impacts on regional hydrological cycle. Increasing of both negative Southern Oscillation Index (SOI) (El Niño) and positive SOI index (La Niña) are responsible for the decrease in NDVI. The present results show that both El Niño and La Niña years affect the regional vegetation growth significantly.

P-EC1.2

Satellite-derived MODIS Vegetation Attributes: Indicators of Climatic Effects on Biodiversity and Productivity Across the U.S.A.?

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Our general tenet is that modeled and observed responses of terrestrial vegetation to climatic variation must be expressed and measured in a standardized, readily interpretable manner to be useful to policy makers and justifiable to the public. Long before successional alterations in vegetation composition are noted, climatic variation induces changes in the initiation, duration, and effectiveness of the growing season. A recently developed Growing Season Index (GSI) shows the ability to estimate seasonal vegetation activity (net CO_2 flux) at a monthly time-scale across a full range of vegetation types within the contiguous USA. The computed GSI agreed ($R^2 \geq 0.8$) with the monthly patterns exhibited by the MODIS Enhanced Vegetation Index (EVI) in seven level II EPA defined ecoregions dominated by forest (mixed, deciduous and evergreen) vegetation. Relationships between monthly GSI and the EVI were not as robust ($R^2 \geq 0.5$) for the remaining 14 ecoregions with less developed canopies, such as those dominated by grassland, savannas and shrublands. Growing season photosynthetic activity was also well characterized at monthly intervals using MODIS EVI data. For dominant vegetation types within each ecoregion there was a significant positive linear relationship ($R^2 = 0.72$) between annual maximum mean GSI, representing potential productivity, and maximum MODIS EVI. With the availability of MODIS-derived products displaying variation in vegetation activity, we advocate that this globally available technology be considered as a general tool to evaluate the extent that regional changes in climate affect current vegetation. Indirectly, the EVI may have additional value to indicate changes in biodiversity as it accounts for 68% of observed variation in tree richness patterns across 65 forested level III EPA defined ecoregions across the United States.

P-EC1.3

Altered Climate and Ecosystem Response: The Long-Term Ecological Research Program (LTER)

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Here we provide examples from the LTER network on the current state of observations, modeling, and research on altered climate and ecosystem response, with an emphasis on providing input to decision makers. The National Science Foundation established the LTER program in 1980 to support research on long-term ecological phenomena in the United States. Currently the 26 LTER Sites represent diverse ecosystems and research emphases, involving more than 1,800 scientists and students investigating ecological processes over long temporal and broad spatial scales. We build on the mission of the LTER program to provide policy makers and society with the knowledge and predictive understanding necessary to conserve, protect, and manage the nation's ecosystems, their biodiversity, and the services they provide. We provide example applications of scientific information to support decision making, including: (a) changes in climate and carbon sequestration in the Great Plains (Konza LTER) and western high-elevation forests (NWT LTER); and (b) potential for increased desertification at the Jornada LTER site in the southwestern U.S. Within these examples, we stress new methods for communicating scientific information, including incorporation of information about levels of confidence and uncertainty in decision making, and methods and metrics for evaluating outcomes.

P-EC1.4

Climate LINKages of UPland–Lowland Environments (LINKUP)

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A conceptual view has emerged in climate and global change science of the interconnectedness between natural ecosystems and the larger environment within which it operates. While the concept is sometimes applied to natural living systems that exclude human beings, the impact of human activities, which affect the operation of physical and ecological systems on a variety of space and time scales, must be included in the development of future scenarios of the impacts of climate change.

The western portions of the United States have experienced tremendous population growth, which is changing the fabric of the urban and rural landscapes across the region. The physical chord that connects the entire palimpsest of western history to the present time is water—its scarcity on the landscape and the riparian corridors that connect upland and lowland environments. In effect, the streams, which begin high in the North American Cordillera and bring water to the densely populated western "lowlands," can be thought of as a vast "vascular system" pumping the lifeblood of the region.

In the last 30 years changes in the climate of the region already have brought about inter alia, measurable changes in plant phenology, in the seasonal cycle of snowmelt and streamflow, in the rate of growth and disturbance of high elevation forest conifers, and in the drought cycles that are an integral part of the growth dynamics of grasslands and open woodlands in the West. It is the purpose of this presentation to consider some of the implications of these changes in the climate of the western United States, paying particular attention to impacts that are already being manifested in the landscape and climate of the region: from forested and meadowed uplands, through the lower border grasslands and riverine systems that connect them, to some hyper-arid areas in the lower reaches. The presentation will focus on an assessment of the capacity of the current climate observing system to allow decision makers to recognize and foresee future changes in water resources due to changes in the hydroclimatology of the region, and to inform possible preparations for future water shortages. CCSP Themes: Water (drought, water supply), ecosystems, energy (hydropower).

P-EC2.1

Addressing the Impact of Climate Change on Wildland Fires

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In 2003, wildland fires in Southern California claimed 22 lives, destroyed 3,600 homes, burned nearly 740,000 acres of land, and caused more than $2 billion in property damage. As our Nation's population continues to grow, homes and other development press against the boundaries of public and private wildlands and rural areas. This interface between communities and wildlands and rural areas, called the wildland-urban interface, is where wildland fire can have its potentially greatest impact (e.g., loss of life and property).

Climate can play a significant role in conditions leading to and sustaining wildland fires. For example, climatic events, such as El Niño and prolonged heat waves, can lead to fire-prone areas where wildland fires are easily sustained because of the abundance of dry fuels. These climate-induced wildland fires can impact ecosystem health as well by destroying the environment of animals and endangered species (both plant and animal) and eliminating source areas of rich carbon dioxide needed for the balance of our atmosphere. Wildland fires also can directly impact the quality of our water supplies. Sediments from burned areas can be washed down into rivers adversely impacting a community's primary source of water. Finally, wildland fires, a major contributor of toxic air pollutants and particulate matter, have potentially detrimental health effects because they can penetrate deep into the human lungs and may cause a whole range of health problems.

Climate information can be more fully exploited in planning and executing wildland fire policy, processes, and procedures. One example of using climate information deals with the decisions for prepositioning equipment and personnel in advance of the fire season. The Climate Ecosystem and Fire Application Program at the Desert Research Institute in Reno, Nevada, along with the National Predictive Services Group, the University of Arizona, and NOAA's Office of Global Programs conduct yearly workshops for the purpose of creating a "one voice" seasonal fire potential outlook. The outlooks have begun to provide fire managers with the tools they need for providing quick response to wildland fires, but more can be done.

The Office of the Federal Coordinator for Meteorological Services and Supporting Research (OFCM), an interdepartmental office with the mission to ensure the effective use of federal meteorological resources, will lead an interdisciplinary effort to conduct a comprehensive national wildland fire weather and climate needs assessment. This poster highlights the impacts of climate change on wildland fires and provides a synopsis of the plans for the national assessment.

P-EC2.2

Keepers of the Flame: The Role and Use of Climate in National and Regional Fire Policy

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Since 1910, the U.S. Forest Service has developed and transformed policy for wildland fire suppression and management of federal lands utilizing prescribed fire and fire use. The fire management issues of today have evolved from 100 years of influence from three shaping factors—fire management practices, land use activities, and climate. All three have been on parallel but related paths. Some specific fire events have initiated or changed policy and hence management practices. Expectations have evolved from forests once being primarily an agricultural economic benefit, to now largely one of aesthetics and recreation, in the process creating the "wildland-urban interface". New management strategies have evolved in attempts to address not only tradeoffs between social and biological benefits but competing ecological values. Wet and dry climate periods have changed fuel characteristics, but are also related to both management practices (e.g., response strategies during drought) and the West's dramatic population growth.

In this presentation we argue that the benefits of climate information can be realized in both operational and constitutive or policy formulation settings. The role and use of fire has evolved into one of recognition of the value of fire in ecosystem processes and not simply one of "fire as hazard." We review the evolution of national and regional fire policy and identify the potential and practical role for climate information in improving the outcomes identified within these strategies. More precisely we document (1) Policy changes: What was learned between 1994-2000 about prevention, suppression and the role of climate (and do the budgets reflect these lessons?); (2) Climate-sensitive factors which drive up firefighting (suppression and mitigation) costs; (3) Federal/state policies and programs that might experience increased fire risks and severity if climate is not taken into account within present fire preparedness plans; (4) Reforms that have been proposed. We show how consideration of climate variability and change may necessitate a paradigm shift in land management or at least in the assumptions inherent in management plans. Lessons are drawn from recent major fires and fire hotspots in the western United States.

We show that a proactive risk assessment approach, which incorporates cross-scale climatic information including forecasts, can improve policy formulation and implementation in several areas. These include processes for identifying and developing: 1) Methodologies for measuring, evaluating and reporting fire management efficiency. 2) Alternatives at the national, regional, and local needs (e.g. a single federal fire organization, contracts). 3) Long-range interagency wildland fire management objectives based on values to be protected. 4) Input into interagency preparedness planning based on established wildland fire objectives to facilitate adaptive management.

P-EC2.3

Using Fire and Climate History for Assessing Current and Future Fire Hazards

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Many forest and woodland ecosystems in western North America have undergone extreme changes during the past century, leading to increased hazard of high severity fires. In addition to forest structure and fuel changes, increased numbers of people living in these environments, and extreme droughts in recent years have led to extraordinary fire events, burning the largest areas in more than a century, destroying hundreds of homes and businesses, and damaging watersheds and habitats. Better management of forests and fire problems in the future, especially under changing climate conditions, will require the use of spatial/temporal analytical tools and datasets to map the current and anticipated fire hazards. We have developed a prototype tool for such analyses called "Wildfire Alternatives" (WALTER, http://walter.arizona.edu/). This presentation will focus on the use of spatial/temporal fire and climate histories in the western United States for assessing climate-related changes in fire hazard, and the WALTER analytical tool as an example of decision support for managers.

P-EC2.4

Using Satellite-Based Fire Products to Enhance the National Emissions Inventory

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Fire is a natural process that is directly influenced by weather and climate and in turn feeds back to the climate system by releasing stored carbon, emitting a host of atmospheric gases and aerosols, altering rainfall patterns and changing landscape-scale albedo (relative reflectivity). Although biomass burning is a major contributor of particulate matter and other pollutants to the atmosphere, it is one of the most poorly documented of all source emissions in the United States. Biomass burning can be a significant contributor to a regions inability to achieve the National Ambient Air Quality Standards for PM 2.5 and ozone. Currently, the United States does not have a standard methodology to track fire occurrence or area burned, which are essential components to estimating fire emissions. One problem is the ownership and management of the land belongs to multiple organizations and private individuals, so there is not one organization that is responsible for thoroughly monitoring fire. Satellite imagery provides the opportunity to remotely sense fire across boundaries.

In this talk, we will highlight the ability of satellite-based fire products to detect active fire, and we will describe how this information will assist the existing Environmental Protection Agency and Regional Planning Organization Decision Support Structure. In an effort to enhance existing area burned databases and emissions estimates, two satellite-based fire products are compared temporally and spatially to ground-based data from Florida. The satellite data are coincident with 14% of the reported ground fires, and 25% of the satellite data are coincident with the ground data. When considering the spatial resolution of the instruments, a coincidence of 54% exists between the satellite and ground-based data. Additionally, we identified two regions where fires have burned that are detected by the satellites, but these fire events are not recorded in the ground data. We suggest that satellite data can be used to augment the existing ground-based fire dataset to enhance emissions estimates, thus enhancing the National Emissions Inventory and the ability of the Regional Planning Organizations and the Environmental Protection Agency to attain their goals.

P-EC2.5

The MODIS Rapid Response Project: A New Suite of Remote Sensing Products in Support of Decision Making

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The Moderate-resolution Imaging Spectroradiometer (MODIS) instrument on board NASA's Terra and Aqua polar-orbiting satellites offers an unprecedented combination of daily spatial coverage, spatial resolution, and spectral characteristics. These instrument capabilities make MODIS ideal to provide observations in support of decision making for a variety of rapid events: active fires, floods, smoke transport, dust storms, severe storms, iceberg calving, and volcanic eruptions. A new processing system was built in 2001 at NASA's Goddard Space Flight Center to provide a rapid response to those events, with initial emphasis on active fire detection and 250m-resolution imagery. MODIS data for most of the Earth's land surface is now processed within a few hours of data acquisition by the MODIS Rapid Response System and delivered to several decision-making systems.

A collaboration between NASA, the University of Maryland and the U.S.D.A. Forest Service was developed to provide fire information derived from MODIS to federal fire managers. Active fire locations in the conterminous United States are automatically produced by the MODIS Rapid Response System and communicated to the U.S. Forest Service within a few minutes of production to generate regional fire maps over the United States, updated four times daily and distributed to the fire managers to help them allocate firefighting resources. Active fire locations are also distributed in near-real-time to the Global Observation of Forest Cover/Global Observation of Landcover Dynamics (GOFC/GOLD) user community by the University of Maryland through the Web Fire Mapper, a web interface integrating MODIS active fire locations and Geographic Information System (GIS) datasets.

The initial suite of MODIS fire products has now been augmented with more rapid products, such as Vegetations Index, in response to users requests. New applications were developed with applications users in need for specific products, data formats, or delivery mechanisms. In particular, the MODIS Rapid Response System has the capability to accommodate specific requirements of existing decision support systems.

For example, a partnership with the U.S.D.A. Foreign Agricultural Service was initiated to generate custom near-real-time MODIS data to help improve the accuracy and timeliness of the crop yield predictions worldwide, which are needed to make decisions affecting U.S. agriculture, trade policy, and food aid. New system capabilities and services such as spatial subset subscription or event-triggered rapid alert were also developed. Recent accomplishments of the MODIS Rapid Response System are shown. Examples of products generated by the system and existing applications are presented.

P-EC2.6

Statistical Modeling of Western Wildfire Season Severity for Decision Support

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The incidence of large wildfires is strongly influenced by climate variability via its effects on the availability of water for the growth and wetting of the vegetation that serves as fuel. Its strong links to climate variability and hydrology and its large economic impact make western U.S. wildfire a natural application for climate information services. At the California Applications Program, part of the NOAA RISA program, we provide wildfire research, modeling and forecast development to federal and state land management agencies. In this talk we will summarize research, products and stakeholder interactions for three applications of climate information to support fire and land management.

Seasonal wildfire area burned forecasts for the National Interagency Coordination Center's Predictive Services (NICC): The NICC disseminates climate and fire forecasts to fire weather and climate specialists who support fire management operations by state and federal land managers, and coordinates fire suppression resources locally, regionally, and nationally. We developed seasonal area burned forecasts that are prepared in January, February and April to support preparation of NICC seasonal fire outlooks.

Annual wildfire area burned and suppression costs forecasts for USDA Forest Service budgeting: USDA Forest Service budget managers customarily use the average of 10 preceding years to forecast fire activity and related suppression expenditures. Since wildfire activity is highly variable on interannual and decadal time scales, the Forest Service regularly exceeds its suppression budget, causing considerable disruption to other activities funded by the Service. At their request, we have assisted in the production of climate-based suppression cost forecasts for the Forest Service in March of the last three years. Currently, we are working with them to assess experimental long lead forecasts for use in allocating resources within the Forest Service budget at the start of their fiscal year in October.

Climate change impact assessment for wildfire for the State of California: At the request of the State of California, we are modeling wildfire activity for a range of emissions scenarios and global climate models. We will provide a preliminary climate change impact assessment for the California state legislature in January 2006, describing the incidence of large fires, area burned, and property losses. This work is supported by the California Energy Commission.

Wildfire management is a key component of ecosystem management in the western United States with significant potential to benefit from the integration of climate information into decision making.

P-EC3.1

Decision Support Tools for Adaptive Forest Management

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Scientific understanding of ecosystems recognizes that ecosystem structure, function and health represent a continual balancing of ecosystem processes within a climate framework. Although ecosystem managers are aware of that scientific understanding as they assess, plan, set policy and adaptively manage, they still use Decision Support Tools (DST) that generally fail to incorporate climate variability and change. Those managers are now asking how they should adjust their DST in the face of predicted climate change.

Forest ecosystems are a particularly worrisome subset. The lifespan of their identifying component (trees) is long in relation to the time scale of significant change. They are a central reservoir and supplier in regard to water, carbon, wildlife, recreation, timber, flood control, and too many other resources to list. Science recognizes that disturbance is the most rapid mechanism for forest ecosystems to seek adjustment to changed environmental forcing conditions. An accepted scenario for forest-based disturbance is drought stress leading to insect outbreaks leading to catastrophic fires leading to new growth. However, the new growth will not replicate the previous ecosystem when climate variability, climate change, and invasive species come to play a significant role. Whether they manage for wildlife habitat along the Gulf Coast, timber in Georgia, recreation in the Boundary Waters of Minnesota, the Wildland Urban Interface in California, or Salmon in the Pacific Northwest, today's forest ecosystem managers face unprecedented assessment, planning, policy and adaptive management challenges increasingly framed by climate variability and change.

To meet these challenges, the decision makers and scientists who support them must rapidly evolve a set of DST based on integrated observational systems, employing coupled predictive modeling, and presenting information in a risk based probabilistic framework. Climate scientists are best equipped, in fact should feel responsible, to initiate a concerted drive to meet this need. This paper details a logical pathway to this end by including risk assessment in adaptive management DST approaches for forest ecosystem management. Underlying science will view climate and disturbance driven ecosystem processes in the face of forest fries and demographic trends. Specific components of an integrated observational system to operationally supply the envisioned DST will be identified. Many of the necessary components exist or are being actively worked on today. But climate scientists and natural resource managers will both need to apply concerted pressure to align those components to meet the need for DST in support of adaptive forest management for changing climate.

P-EC3.2

Interim Wildlife Management and Global Climate

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A key challenge for wildlife management decision makers is the expectation that their present day management choices will enhance wildlife populations now and in the decades ahead, even as the climate changes. The dilemma facing decision makers is that global climate change is likely already affecting local wildlife populations but there is a paucity of quantitative information regarding these and likely future impacts. Public expectations, despite climate change, include maintaining game wildlife populations at harvestable levels and conserving endangered species (which are especially vulnerable to climate change). The many other factors (pollution, habitat fragmentation and loss) already affecting wildlife and their habitats make successfully addressing climate change effects even more challenging.

This paper reviews 18 specific adaptive management and planning actions (Inkley *et al*. 2004) which decision makers can take now to best conserve wildlife until better qualitative information on the scope and impacts of climate change become available. These interim recommendations include planning for surprises, reducing the risk of catastrophic fires, monitoring and adaptive management, reduction of non-climate stressors on ecosystems, and adjusting yield and harvest models. The type of information that decision makers need to inform their interim management recommendations is presented and discussed.

Inkley, D.B., M.G. Anderson, A.R. Blaustein, V.R. Burkett, B. Felzer, B. Griffith, J. Price, and T.L. Root. 2004. *Global climate change and wildlife in North America*. Wildlife Society Technical Review 04-2. The Wildlife Society, Bethesda, Maryland, USA. 26pp.

P-EC3.3

Redesigning Conservation for Climate Change

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Conservation and resource management has long been considered in terms of spatial scales (reserve design, corridors, minimum habitat size, etc...). Climate change requires that this paradigm be changed and that temporal considerations figure more prominently in resource management. We must consider how systems will look in 5, 10 and 50 years, not just today. In order to meet these changing decision support needs we are conducting field studies to determine what factors are key in increasing the resilience of ecosystems to climate change. In this talk the basic tenets of such work will be discussed and case studies will be presented.

P-EC4.1

A Modeling Study of Climate-Ecosystem Interaction Over North America

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We used a regional climate version of the MM5 mesoscale atmospheric modeling system that was asynchronically and simultaneously coupled with the biogeographical model BIOME to explore vegetation-climate interactions over North America. The impact of climate change due to increased greenhouse gases on potential ecosystem evolution was assessed, and a future scenario of vegetation distribution was explored. Doubled CO_2 conditions induced strong high-latitude warming, while the southern U.S. became cooler in winter. Across almost all of the model domain precipitation tended to increase in all seasons with the highest intensification found over the Northeast, Southeast, and the Great Plains. In response to this future climate scenario, vegetation migrated northward systematically in the eastern United States. In particular, strong warming under the doubled CO_2 condition was simulated at high latitudes, and subsequently the sparsely vegetated area around Hudson Bay was predicted to be covered by cool conifer forests in the future warming climate. Over the Great Plains and part of the Midwest, water supply is the crucial factor that affects natural vegetation evolution, and more precipitation under doubled CO_2 led to temperate deciduous forests extending toward north and northwest. Grasslands in the northern half of the Great Plains will be replaced by cool conifer and mixed forests due to more precipitation in the future. However, no systematic changes in vegetation were predicted over the Rocky Mountains and Cascades in the West, partly due to the complex terrain and unsystematic changes in temperature and precipitation in the region. Averaged over the whole model domain, 39% of vegetation types has changed under doubled CO_2. Above results are based on model simulations using 108 km resolution, and they will be compared with runs using 50 km resolution to study the potential impact of model resolution on regional ecosystem response to climate change.

P-EC4.2

Transient Dynamics of Vegetation Response to Past and Future Major Climatic Changes in the Southwestern United States

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Predicting the effects of major climatic change on plant species requires both knowledge of the plant's climate tolerances as well as an understanding of the transient dynamics of massive change on ecological communities. The climatic tolerances of species can be modeled through geostatistical analyses of their Twentieth Century ranges and climates. These models can then be applied to GCM predictions of future climates in order to plot future regions of potential acceptable climates for each species. Unfortunately, in the topographically diverse southwestern U.S., these models of future potential climate space are of limited use unless they can be extrapolated to a meaningful landscape scale. In our research, we have modeled plant distributions, Twentieth Century climates, future GCM modeled climates, and future potential climate space for several species to a ~1 km grid scale. Future seasonal climate values were developed from monthly ~75 km output from the CCM3 model results downscaled using the delta-change technique. These modeled future distributions only represent areas where a species could potentially persist, not areas where a species is likely to occur. In order to distinguish a species' future potential climate range from its future likely range, we have designed spatial models incorporating the dynamics of change, especially migration. These models are parameterized using fossil data from species response to past examples of rapidly warming climate. Recent data from the desert southwest suggest that at the end of the Younger Dryas Period, 11,600 years ago, winter minimum temperatures rose at least 4.1 degrees C over a time span of less than 200 years. This abrupt temperature warming is the most recent analog in both pace and magnitude and for the changes expected in this region over the next 100 to 150 years. Abundant plant fossil records allow reconstruction of the ecological dynamics and plant migrations in response to this sudden warming event. Our results thus far demonstrate dramatic differences in future projected distributions for plant species, both in terms of the extent of their potential climate space and in their ability to respond to changing climates. For example, two large desert succulents characteristic of the southwestern deserts respond in opposite ways the projected changes in climate. The potential range of Joshua Tree (Yucca brevifolia) is not only reduced and shifted northward by climate change, but the plant's lack of dispersal mechanisms should reduce its actual extent by at least 90%. In contrast, the potential range of giant saguaro, (Carnegia gigantea) expands in all directions from its current range, and the plant's dispersal, aided by numerous animal vectors, should ensure its capability to take advantage of much of this expanded range.

P-EC4.3

Potential Widespread Forest Dieback in North America: What is the Price of Uncertainty

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The dynamics of North American "natural" ecosystems were assessed under 6 future climate scenarios and included changing carbon balance, vegetation distribution and fire disturbance. The VINCERA project (Vulnerability and Impacts of North American forests to Climate: Ecosystem Responses and Adaptation) is an intercomparison among three dynamic general vegetation models (DGVMs). The scenarios are from the Canadian Climate Centre (CGCM2), the Hadley Centre (HADCM3) and Australia (CSIRO-MK2), each using two SRES trace gas emissions scenarios, A2 and B2. The three DGVMs are MC1, IBIS and SDGVM. We will present results from MC1 and SDGVM at a minimum, and possibly IBIS as well. SDGVM shows continual growth in all biomes through the 21st century; while MC1 shows an "early greenup—later browndown in most biomes." The difference is due to the direct CO_2 effect wherein SDGVM demonstrates a productivity and water use efficiency increase from current to 700 ppm CO_2 of about 58% compared to a range of 13 to 19% for MC1. The MC1 simulations produce a period of growth followed by significant dieback especially in eastern U.S. forests under all scenarios. The point of turnaround from greenup to browndown occurs about now for the temperate forests and about a decade from now in the boreal forests. The boreal forests shift into the taiga-tundra open woodland, but then experience another dieback in mid-21st century. There are also excursions of the central grasslands into the boreal forest zone. Dieback is triggered under two mechanisms. Reduced regional precipitation, variable among the scenarios, is one mechanism for dieback. However, a more insidious and pervasive effect is due to the influence of rising temperatures on evapotranspiration (ET) and the lengthening of the growing season. Even with the benefits of enhanced water use efficiency from elevated CO_2 and slight increases in precipitation, increases in temperature can produce widespread, very rapid forest dieback, followed by infestations and fires. Large areas of the eastern U.S. appear to be particularly vulnerable to this sequence of processes, as does the central boreal forest, due to the relatively flat regional climates. Dieback is driven by both increasing temperatures and decreasing precipitation in some regions under some scenarios, notably the Southeastern U.S. and the Northwestern U.S. Fire suppression can mitigate much of this loss, but will be costly. These results underscore the critical importance of addressing the uncertainties with respect to ecosystem water balance and the direct effects of elevated CO_2 concentrations.

P-EC4.4

Vulnerability of Northern Prairie Wetlands to Climate Change: Implications for Waterfowl

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The Prairie Pothole Region (PPR) lies in the heart of North America and contains millions of glacially-formed, depressional wetlands embedded in a landscape matrix of natural grassland and agriculture. These wetlands provide valuable ecosystem services and produce 50-80% of the continent's ducks. We explored the broad spatial and temporal patterns across the PPR between climate and wetland water levels and vegetation by "moving" a wetland model (WETSIM) among 18 stations with 95-year weather records. Simulations suggest that the most productive habitat historically for breeding waterfowl would shift under a drier climate from the center of the PPR (Dakotas and southeastern Saskatchewan) to the wetter eastern and northern fringes, areas currently less productive or where most wetlands have been drained. Unless these wetlands are protected and restored, there is little insurance for waterfowl against future climate warming. WETSIM can assist wetland managers in allocating restoration dollars in an uncertain climate future.

P-EC4.5

Eastern Deciduous Forest Responses to Climatic Change Drivers: An Upland-Oak Forest Case Study

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Mechanistic ecosystem models represent the scientific communities' primary method for evaluating complex multi-scale responses to climatic change, and the logical tool for testing hypotheses about ecosystem responses to specific scenarios of change. In this poster we provide examples of the abilities and limitations of ecosystem models to handle current environmental variations for upland-oak forests of the eastern United States and discuss their use for predicting forest responses to future climatic conditions. Current ecosystem models for deciduous forests are equipped to reproduce short-term physiological responses for historical environmental conditions, but have more difficulty capturing responses to past extremes (e.g., severe drought). An ensemble mean of multiple model outputs was shown to produce robust near-term predictions for a case-study upland-oak forest, and such an approach is likely to benefit model simulations conducted in support of other decision making processes.

Model simulations are only as good as experimentally derived knowledge of plant and ecosystem responses to environmental change. The ability of plants to acclimate to environmental change over time, the development of internal feedbacks from biogeochemical cycles, and changes in the seasonality of ecosystem processes all represent indirect, experimentally observed response drivers that must be incorporated into ecosystem models. Data for an upland-oak forest indicate that existing model codes need to incorporate "lessons learned" from large-scale experimental manipulations of temperature, elevated CO_2, ozone and precipitation to avoid serious over or under predictions of long-term ecosystem responses. Furthermore, although many models have been developed to simulate carbon, water, and energy exchange between forests and the atmosphere, comparatively few mechanistic models are equipped to simulate long-term productivity changes and mortality patterns that are of primary interest to decision makers. Conversely, models designed to predict plant succession typically have insufficient mechanistic rigor to incorporate the key physiological adjustments by plants and ecosystems revealed from experimental work.

A key goal of the U.S. Climate Change Science Program is to understand the potential consequences of global change for ecological systems. Few ecosystems, however, have been adequately studied in sufficient detail to derive policy-relevant conclusions directly from experimental data. Our results from experiments and modeling of upland-oak forests indicate that ecosystem forecasts relevant to decision making must be mechanistically sophisticated and based on rational scenarios of future climatic change if they are to logically address effects of future environmental changes.

Funding for this work was provided by the U.S. Department of Energy (DOE), Office of Science.

P-EC4.6

Rising Atmospheric Carbon Dioxide as a Factor in the Success of Invasive Weeds

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Because international trade has increased the biotic mixing of flora across the globe, unwanted plant species are becoming widely established. The severity of damage induced by these species and their panoptic scale have produced a new class of unwanted plants, termed "invasive" or "noxious" weeds. Such invasive species are present in both managed (e.g. Canada thistle in agriculture) and unmanaged systems (e.g. cheat-grass in chaparral). To determine whether rising levels of atmospheric carbon dioxide (CO_2, the principle global warming gas) has been a factor in the success of such species, we have compared the potential response to recent and projected increases in CO_2 relative to other plant groups. Overall, data from our laboratory and other researchers indicates that invasive, noxious weeds, on the whole, have a larger than expected growth response to increasing CO_2 levels above the pre-industrial baseline. There is also increasing evidence that rising CO_2 can, in fact, preferentially select for these invasive, noxious species within plant communities. In addition, there is initial data suggesting that chemical control of such weeds may be more difficult in the future. However the small data set available to researchers and policy makers make such conclusions problematic, and emphasize the urgent need for additional investigations to address the biological and economic uncertainties associated with the role of rising CO_2 in the success and spread of invasive weeds.

P-CA1.1

Using Ecosystem Models to Inventory and Mitigate Environmental Impacts of Agriculture

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As a provider of climate change information, the presenter will discuss how ecosystem models can be used to asses and mitigate some environmental impacts of agriculture. Agriculture is the source of ~20% of global radiative forcing from the most important long-lived greenhouse gases (GHG's): carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Agriculture is a relatively small source of CO_2, but is responsible for ~50% and ~70%, respectively, of the anthropogenic emissions of CH_4 and N_2O. Agriculture is also the primary contributor of eutrophication of aquatic systems from nutrients that are runoff or leached from cropped fields into water ways. Thus, there exist potential to mitigate the impacts of agriculture on GHG emissions and water quality. The authors have developed inventories to estimate national emissions under present conditions which can also be used to identify areas that have large mitigation potential. For example, carbon (C) sequestration in agricultural soils has been suggested as a way to reduce national GHG emissions but inventories generated by the authors show that CO_2 emissions from histosol (organic soil) cropping nullifies >50% of the C sequestered in non-histosol cropped soils even though histosols occupy <1% of total US cropped land. Because it is not feasible to measure emissions at regional and larger scales, national inventories employ models. The authors are using the CENTURY and DAYCENT ecosystem models to estimate emissions from major cropping systems for the US national inventory. Models used to establish emissions under current management practices can also be used to compare alternative management scenarios intended to reduce emissions. For example, projected crop yield, soil C, and GHG outputs from CENTURY and DAYCENT have been linked with economic models to evaluate the costs/benefits of competing management strategies at the global scale. Although the use of ecosystem models in GHG inventories has increased confidence in emission estimates, there remains considerable uncertainty regarding both the estimates of GHG emissions under typical management practices and the extent to which these can be reduced under alternative management scenarios. Inventories can be improved and uncertainties reduced by increasing resources to collect field data for model/data comparisons and to acquire more refined activity data needed for model inputs.

P-CA1.2

Renewable Energy as an Emission Control Alternative: Agricultural and Forestry Sector Roles

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One potential way of reducing net greenhouse gas emissions is through the use of renewable energy sources. Agriculture and forestry are important potential producers of renewable energy. Plant based materials from agriculture and forestry can be used directly as input to electricity generation or may be transformed into liquid fuels. Use of such feedstocks constitutes an opportunity to reduce net carbon emissions as plant growth removes carbon from the atmosphere via photosynthesis and then combustion releases that carbon. As a consequence, agriculture and forestry based feedstocks provide greenhouse gas recycling with the potential for reduced emissions relative to use of conventional fossil fuels. The net greenhouse gas balance when employing such strategies depends upon the amount of fossil energy and associated greenhouse gas related emissions that are incurred in growing, transporting and transforming the plant based feedstocks into energy.

This presentation reports on the prospects for agriculture and forestry playing a major role in energy generation. Pathways are considered for the development of electrical energy, gasoline replacements, and diesel replacements. Feedstocks can arise from crop and logging residues, energy crops, conventional crops, and agricultural oils. Results will be presented from a comprehensive consistent appraisal across all of these feedstock/energy replacement possibilities. Appraisal results will be presented on greenhouse gas efficiency, environmental impacts including air quality and economic conditions under which the renewable possibility makes sense in terms of energy prices and greenhouse gas offset prices.

P-CA1.3

Estimating U.S. Forest-Agriculture Climate Change Mitigation Opportunities at the National and Regional Scales using Economic, Policy, and Co-Benefits Criteria

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U.S. forest and agricultural lands comprise a net carbon sink of 830 Tg CO_2 equivalent per year (for 2003), 90 percent of which is in forests, and offer significant potential for further greenhouse gas (GHG) mitigation. Decision makers require data and enhanced tools to evaluate mitigation options in terms of their magnitude, location, activity mix, timing, costs, and other (non-GHG) co-benefits. This information is needed at various scales: project, regional, and national.

Biophysical mitigation potential from forestry and agriculture is large, but only some fraction may be achieved by landowners under certain policy assumptions (e.g., eligibility restrictions), and economic incentives (e.g., carbon prices). The price-endogenous Forest and Agricultural Sector Optimization Model (FASOMGHG) is used to assess mitigation potential through the lens of economic, climate policy (e.g., baseline, leakage), and co-benefit (e.g., water quality) factors. Results for 2010-2110 (and focus years 2015, 2025, and 2055), are presented for six scenarios covering constant and rising GHG prices; fixed national mitigation levels; selected mitigation activities; and various incentive payment systems.

GHG reduction incentives can generate total national mitigation—relative to the baseline—averaging 630 Tg CO_2/yr (170 Tg C) in the first decade, 655 Tg CO_2/yr by 2025, declining to 85 Tg CO_2/yr by 2055, under a constant \$15 t/CO_2 Eq scenario. The optimal portfolio and timing of mitigation is affected by GHG prices. At low GHG prices (≤\$5/t CO_2 Eq.) and in early years, carbon sequestration in agricultural soils and in forest management dominate; afforestation dominates at middle to higher prices (≥\$15/t CO_2 Eq.) to 2050; but the GHG benefits of these options get reversed by 2055. Biofuels dominate the portfolio at the highest prices (\$30 and \$50/t CO_2 Eq.) and in years beyond 2050. Mitigation potential is not regionally uniform. The South-Central, Corn Belt, and Southeast regions possess the largest GHG competitive potential; the Rockies, Southwest, and Pacific Coast the least. Incentive structures are important. If a national GHG mitigation quantity in a given year is an objective, but economic incentives do not continue after that date, then carbon sequestered in previous decades may be completely reversed. Leakage of GHG benefits to other regions may be significant if only selected activities (e.g., afforestation) are eligible for mitigation, and may vary by activity, region, and over time. GHG mitigation can have substantial non-GHG environmental co-effects. Even a low GHG price (e.g., \$5/tonne) can induce changes in tillage practices and soil carbon sequestration, and reduce erosion and nutrient run-off.

P-CA1.4

A Modeling Framework to Relate Agricultural Practice, Land-Use Change, Energy Use, and Greenhouse Gas Emissions on Agricultural Lands in the USA: Integrating Carbon Accounting with Survey Data, Remote Sensing, and Economic Modeling

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A spatially-explicit modeling framework is currently being developed to monitor and model changes in greenhouse gas emissions from U.S. agricultural lands, including carbon sources and sinks, at the county scale. National survey data are being combined with greenhouse gas coefficients to estimate lateral transport of carbon in agricultural products and the net C-equivalent flux of greenhouse gas emissions to the atmosphere. The primary data used for these estimates are being linked within a larger framework to facilitate revision on a regular basis. Agricultural input data and greenhouse gas coefficients are being combined with an agricultural economic model to model changes in land use, energy use, and greenhouse gas emissions that might occur on agricultural lands following changes in energy, agricultural, or climate change policies; or incentives that might be provided for carbon sequestration. With respect to carbon uptake, transport, and respiration, preliminary estimates for 2000 indicate that 495 Tg C were taken up from the atmosphere by agricultural crops, of which 209 Tg C were harvested and transported laterally throughout the country and then respired by livestock (77 Tg C) and humans (31 Tg C). Annual changes in soil carbon and the energy and emissions associated with agricultural inputs are also being monitored, and preliminary results will be presented. The estimates provided here are delineated spatially at the county level. Methods for delineating carbon transport and greenhouse gas emissions at higher resolutions using remote sensing are being developed. This framework will provide information on changes in land use and associated changes in carbon sources and sinks, greenhouse gas emissions, and energy use that would accompany proposed changes in policy.

P-CA1.5

Determining the Long-Term Impact of Bioenergy Crops on the Global Warming Potential of Energy Use

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As a provider of climate change information, the presenter will describe a framework to assess the impact of different bioenergy cropping systems (corn, soybeans, alfalfa, switchgrass, reed canarygrass, and hybrid poplar) on the global warming potential (GWP) of energy use and examine how the long-term impact of those predictions vary with climate change. Reducing the net GWP of energy use is a major factor driving interest in biofuels. Bioenergy cropping systems vary in contribution to the GWP due to the following: crop yield and resulting quantity of fossil fuels displaced by the biofuels produced, change in soil organic carbon and belowground biomass carbon, fossil fuels used in feedstock transport to the biorefinery, conversion to biofuel and subsequent distribution, N_2O and CH_4 emissions, CO_2 emission from N fertilizer manufacture, and fuel used by agricultural machinery for tillage, planting, fertilizer/pesticide application, harvesting, and drying corn grain. To conduct a life cycle analysis of the GWP of bioenergy cropping systems, DAYCENT is used to model the dynamic sources and sinks of greenhouse gases (GHGs). Cropping system practices, such as tillage, plant life cycle, and N fertilizer use have a significant impact on GHG emissions. DAYCENT can integrate climate, soil properties, and land use and can dynamically evaluate the impact of cropping systems on crop production, soil C, and trace gas fluxes, factors critical to conducting a full C cycle analysis of bioenergy cropping systems. This approach to determining the GWP of bioenergy cropping systems can be used to extend evaluations from local to regional scales across the United States. By determining the optimal portfolio of bioenergy crops grown regionally, reduction in GWP can be maximized. This analysis can be expanded to include the impact of climate change on crop production and GWP. Weather data driving climate change scenarios are taken from VEMAP for the baseline scenario with no climate change and from the Canadian Centre for Climate Modeling and Analysis (CGCM1model) and Hadley Centre for Climate Prediction and Research, UK, (HADCM2 model) for the climate change simulations where CO_2 was assumed to double from 2004 - 2100. This modeling approach permits determination of the GWP of bioenergy cropping systems across the United States, including the effect of climate change.

P-CA1.6

COLE: Carbon OnLine Estimation Web Tool for Continental U.S. Forest Ecosystems

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The Carbon OnLine Estimator (COLE; http://ncasi.uml.edu/COLE/) Web tool enables a user to choose a part of or all the forested area of the continental United States, designate subcategories of interest such as owner, forest type, and productivity class, and the tool returns requested reports, estimates, and maps of forest carbon sequestration for that area. Estimates are calculated using traditional forest inventory data collected by the USDA Forest Service, Forest Inventory & Analysis Program, augmented by other ecological data. COLE allows users unfamiliar with these data to produce customized analysis in a short amount of time. The carbon estimates have been used in a number of formats of interest to decision makers, including: greenhouse gas emissions and sinks carbon inventories at the national- and state-level, Montreal Process criteria and indicators for sustainability for maintenance of forest carbon, and as forest carbon growth and yield default tables for the U.S. Department of Energy's Voluntary Reporting of Greenhouse Gases 1605(b) Program. Scientists also use these data to balance the carbon cycles, to validate models or other estimates, or to initiate models. Available forest carbon pools include above- and belowground live tree, dead wood, forest floor, and soil. The JAVA-based user interface is powerful and easy-to-use, and statistical analysis is based on R. A simplified version of COLE is also provided on the website that does not rely on JAVA for those users who have problems running a JAVA-based system on their computer.

P-CA1.7

Spatial Biological and Industrial Carbon Budgets for Northern Wisconsin

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We used satellite remote sensing data as inputs to a forest ecosystem process model that simulates carbon budgets and major carbon fluxes for a national forest, state forest, and non-industrial private forest in Wisconsin. Forest management practices were incorporated into the model to assess carbon cycling and sequestration at the landscape scale for future climate change scenarios. Output from the forest ecosystem process model was compared to timber harvest data and input into a life cycle analysis of forest product chains to quantify sources of greenhouse gas emissions. Using output from the ecosystem model and life cycle analysis, we discuss opportunities in forest management and forest product–related industrial sectors that can be modified to (i) increase carbon sequestration or (ii) mitigate greenhouse gas emissions.

P-CA1.8

Carbon Sequestration Potential in New Mexico Rangelands

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The movement of carbon from the atmosphere and storage in the soil and vegetation (sequestration) is a contribution that agriculture and forestry can make to mitigate the greenhouse effect. Although the process of sequestration is relatively well understood by scientists and land managers, a systematic approach to prioritizing carbon sequestration activities is lacking, especially in the arid and semi-arid west. A regional characterization of carbon sequestration potential is needed so that government incentive programs can be targeted where impacts would be greatest. As part of the Southwest Regional Partnership on Carbon Sequestration, we identified target areas in New Mexico based on spatially explicit climate, soils and land tenure information organized in a GIS format. Once target areas were identified, we assessed baseline carbon for individual soils using COMET-VR, a CENTURY model-based interface to estimate change in soil carbon in response to management practices. COMET-VR was parameterized to predict carbon change under practices consistent with existing federal conservation programs used in New Mexico. Results indicated significant potential to increase carbon storage through changes in land use and management. Achieving that potential, however, is constrained by low rainfall and soil fertility. Broad, landscape scale analysis indicated much of the region would accumulate soil carbon at <0.1 t/ha/y unless changes in land use occur, primarily converting cropland to perennial cover. Land use conversion can result in accumulation rates of up to 1.0 t/ha/y in a limited portion of the state. Increasing soil carbon in the New Mexico will require policy and program decisions that motivate land managers to implement conservation practices on a broad scale.

P-CA1.9

Summer and Winter Precipitation: Effects on Carbon Sequestration and Timber Production under Current and Future Atmospheric CO_2

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When properly and timely supplied by precipitation, water available to forests reduce the proportion of carbon cycling back to the atmosphere, locking higher proportion in a pool of carbon storage that is both relatively long lasting and profitable: the stems of trees. Improperly or untimely supplied, water limitation in summer or ice storms in winter reduce timber production and enhance carbon cycling. At the Duke Forest free-air CO_2 enrichment (FACE) site both drought and nutrient limitation force a larger proportion of carbon assimilated in photosynthesis to cycle back to the atmosphere within a year. Greater water availability and nutrients increased the production of wood and reduced the amount of carbon returning to the atmosphere by an equal quantity. Furthermore, more concentrated atmospheric CO_2 generated extra sugar, some used in wood production and some returned to the atmosphere through microbial respiration. Again, timely precipitation of appropriate quantity, and improved nutrition increased wood production at the expense of carbon cycling back to the atmosphere. Thus, conditions that promote timber production enhance carbon storage in both current and future atmospheric CO_2. Like hurricanes, ice storms are events that can quickly generate large amounts of biomass available for decomposition and cycling back to the atmosphere. In a single ice storm in southeastern U.S., generated in part by anomalously warm Atlantic sea surface temperatures, the loss of carbon was equivalent to 10% of the estimated annual sequestration in conterminous U.S. forests, amounting to about half a billion U.S. dollars in timber. Significantly, the loss in the elevated CO_2 plots was only one third that in the surrounding forest. Thus, future carbon sequestration and timber production will greatly depend on the manifestation of climate change in the temporal dynamics and quantities of precipitation, although elevated atmospheric CO_2 may confer some protection against adverse changes in precipitation, somewhat diminishing the projected negative effects of increased atmospheric CO_2 on climate.

We study the effects of climate variability and change on forest resources at scales ranging up to regions. Our results are relevant to makers of policies aimed at managing water, carbon and timber resources, as well as with organizations concerned with biodiversity and vegetation-ecosystem dynamics. The information we provide is relevant to current issues of water availability, carbon sequestration and timber production, but it is unique in that it predicts the response of an important and widely planted timber species (loblolly pine) to future atmospheric CO_2 under naturally varying climate.

P-CA2.1

Nutrient Management to Enhance Carbon Sequestration in Piedmont Forests of the Southeastern U.S.

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Impacts of alternative forest nutrient management practices on potential C sequestration are poorly understood. In the South Eastern U.S., soils in the Piedmont physiographic province are severely eroded and contain low quantities of soil C as a result of agricultural activity. Conversion of degraded croplands to forests likely has increased terrestrial carbon stocks, although the magnitude of this increase and the impact of forest management on it are unclear because of the lack of long-term data and the high variability in existing soil and plant data. This study examines the potential for carbon sequestration in loblolly pine forests to determine which conventional management practices lead to the most soil carbon sequestration and least adverse environmental impacts at the pedon and watershed scales. Treatment conditions include harvesting during dormant versus active growing seasons, burning versus no burning after harvest, and natural-regeneration versus reseeding (i.e., plantation) of the stand. Burning alters nutrien availability and decomposing roots act as slow-release fertilizer. Data from long-term experiments are used to develop alternative methods to enhance carbon sequestration in terrestrial ecosystems as one component of a carbon management strategy.

P-CA2.2

Unaccounted Soil Carbon Stocks

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Current estimates of world soil carbon stocks are incomplete and inadequate, because most of them are based on actual soil data down to 1 m depth only and were obtained by outdated methods. Thus, soil carbon stocks are severely underestimated. Soil orders such as Alfisol, Aridisol, Mollisol, Ultisol, Vertisol and others contain significant amounts of soil inorganic carbon in the form of carbonates, which often rich maximum content below 1-m depth. Most current soil databases also lack information on soil bulk density, stable carbon geochemistry of soil organic and inorganic carbon distribution, molecular composition of organic carbon therefore limiting our understanding of soil carbon dynamics in the global ecosystem. This study gives an example of improved soil carbon accounting using experimental data from Mollisol, one of the most productive soils in the world.

P-CA2.3

Estimating Soil C Changes for the US 1605B Program "Voluntary Reporting of Greenhouse Gas Mitigation"

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A system for voluntary reporting of greenhouse gas emission reductions was established as part of the US policy for addressing global climate change issues. The system is administered by the USDOE and has recently been revised and improved as part of the Administration's Climate Change Initiative. Emission reductions through agricultural activities, including soil C sequestration and reductions in on-farm fuel usage, are included in the reporting system. The system employs a web-based, menu driven interface, in which producers can designate their location and supply background information on previous land use and management. A variety of management alternatives can be chosen and estimates of C emissions and/or sequestration rates, including statistically-based uncertainty estimates, are provided. Future improvements to the system are under development, including a wider array of management options, defined at finer geographic scale and inclusion of N_2O emissions.

P-CA2.4

Practical Applications of Uncertainty Analysis for National Greenhouse Gas Inventories

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International policy makers and climate researchers use greenhouse gas emissions inventory estimates in a variety of ways. Because of the varied uses of the inventory data, as well as the high uncertainty surrounding some of the source category estimates, considerable effort has been devoted to understanding the causes and magnitude of uncertainties in national emission inventories. In this paper we focus on two aspects of the rationale for quantifying uncertainty: (a) the uses of the quantified uncertainty estimates for policy (for example, as a means of adjusting inventories used to determine compliance with international commitments) and (b) the direct benefits of the process of investigating uncertainties in terms of improvements in inventory quality. We find that there are particular characteristics that an uncertainty estimate should have if it is to be used for policy purposes: (1) it should be comparable across countries; (2) it should be relatively objective or at least subject to review and verification; (3) it should not be subject to gaming by countries acting in their own self-interest; (4) it should be administratively feasible to estimate and use; (5) the quality of uncertainty estimate should be high enough to warrant the additional compliance costs its use in an adjustment factor may impose on countries; and (6) it should attempt to address all types of uncertainty. Currently, uncertainly estimates for national greenhouse gas inventories do not have these characteristics. For example, the information used to develop quantitative uncertainty estimates for national inventories is quite often based on expert judgments, which are, by definition, subjective rather than objective. Although it is not clear that uncertainty estimates will adequately exhibit these characteristics, if they did, the design of any adjustment scheme would require that policy makers (1) identify clear environmental goals; (2) define these goals precisely in terms of relationships among important variables (such as emissions estimate, commitment level, or statistical confidence); and (3) develop quantifiable adjustment mechanisms that reflect these environmental goals. We recommend that countries implement an investigation-focused (i.e., qualitative) uncertainty analysis that will (1) provide the type of information necessary to develop more substantive, and potentially useful, quantitative uncertainty estimates—regardless of whether those quantitative estimates are used for policy purposes—and (2) provide information needed to understand the likely causes of uncertainty in inventory data and thereby point to ways to improve inventory quality (i.e., accuracy, transparency, completeness, and consistency).

P-CA2.5

Spatiotemporally Explicit Maps of Anthropogenic CO_2 Emissions for NACP

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Inverse model studies of biospheric CO_2 exchange at the global and regional scales require accurate spatially and temporally resolved estimates of CO_2 emissions from fossil fuel combustion and other human activities. In this project, we will estimate CO_2 emissions by generating and applying CO_2 emissions factors to underlying variables in EPA National Emission Inventory (NEI) data. Initial maps have been produced by scaling CO or NO_X emissions by regionally specific factors so that annually integrated emissions match annual "top-down" emissions of anthropogenic CO_2. To refine and extend the initial estimates, we will use the Consolidated Community Emissions Processing Tool (CONCEPT) framework to extract NEI estimates of fuel use or other variables for each source category in the major energy use sectors (i.e., industry, electricity, transportation, and buildings) for the US, and to the extent possible Canada and Mexico. We will estimate CO_2 emission factors for each source category, estimate CO_2 emissions for specific sources (for which accurate CO_2 emissions are available), integrate to state and national levels and again compare results with "top-down" estimates of CO_2 emissions at the state and national scales. The results of this work will support the North American Carbon program (NACP) objectives by providing a spatiotemporally-explicit "bottom-up" database of CO_2 emissions from anthropogenic sources for use as a prior estimate in inverse model studies.

P-CA2.6

Time Series Calibrated Carbon Emissions and Atmospheric Response

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Data on population, gross domestic product (GDP), and a combination of nine non-renewable and renewable energy source use rates have been interpolated back to 1700 and disaggregated into 220 reporting regions and used to calibrate a utility optimization model of carbon emissions. Re-aggregating into a tropical/subtropical group (with high rates of population growth and low per capita GDP) and a temperate group (with lower population growth rates and higher average per capita GDP) does *not* reveal empirical evidence for convergence of per capita GDP or per capita carbon emissions between the two groups. The calibration approach allows for the effect on energy and carbon use of fossil carbon depletion, and for a log-linear relationship between production efficiencies and a logistic function of time that is also calibrated against the data set. With continuing recent linear decrease of the carbon intensity of energy production with cumulative carbon use, this approach automatically produces a sensible transition from initial balanced energy and GDP growth to an eventual sustainable state relying on a balanced mix of non-fossil energy sources. Projection of time-series calibrations using this approach gives very limited growth in future global carbon emissions unless and until the historical trends used in the calibration are reversed—e.g. if a "new age of coal" results in an increase in the carbon intensity of energy production as inexpensive fluid fossil fuel resources are depleted and lasts until resulting accumulation of atmospheric carbon triggers an effective agreement on subsequent limitation of carbon emissions. Using temporal averaging to remove short-term temporal autocorrelation and periodic corrections to remove dominant long-term temporal correlations, systematic statistical analysis produces probability distributions for carbon emissions as a function of time. Combining random samples of carbon emissions trajectories with similarly time-series calibrated and sampled parameters from simple linear differential equation models of atmospheric carbon and heat balance yields systematic probability distributions for future change in global average temperature as a function of time.

P-CA2.7

Carbon America: Providing Regional Carbon Emissions and Uptake Information for Carbon Management

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NOAA's Climate Monitoring and Diagnostics Laboratory is well-known for its climate observatories such as Mauna Loa Observatory and its global cooperative carbon dioxide network, currently involving about 100 sampling sites. Not as well known is a pilot project that began over 10 years ago which includes vertical profiling of carbon gases by small charter aircraft and tall (~600 m) communications towers. This project was undertaken because of the necessity to obtain the vertical profile of carbon gases over land in order to sort out diurnal and boundary layer meteorological variations in atmospheric carbon dioxide. This led to a proposal for "Carbon America" a 36-site network of carbon profilers (aircraft and towers), mainly in the U.S., which is now a component of NOAA's Carbon Cycle Atmospheric Observing System. Carbon America is currently about 50% implemented and is expected to be completed by 2008. Data obtained with this network, combined with new meteorological inverse transport models, is expected to lower the uncertainties in the determination of carbon dioxide and methane sources and sinks (emissions and uptake) down to a scale of 500-1,000 km. It is believed that this system can be used to determine a regional CO_2 emission inventory as well as keeping track of the North American carbon dioxide uptake by natural processes and engineered carbon sequestration in the future.

P-CA2.8

Monitoring CO_2 from Space: The NASA Orbiting Carbon Observatory Mission

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The OCO Team

Over the past 30 years, only about half of the carbon dioxide (CO_2) emitted by fossil fuel combustion and other human activities has remained in the atmosphere. The rest has apparently been absorbed by the land biosphere or oceans. The atmospheric CO_2 buildup also varies dramatically from year to year in response to smoothly increasing emission rates. While these properties are clearly revealed by the ground-based CO_2 monitoring networks, this network does not have the spatial coverage or resolution needed to identify the CO_2 sinks or the processes that control them from year to year.

NASA's Orbiting Carbon Observatory (OCO) is being developed to make the first global, space-based observations of atmospheric CO_2 with the resolution and accuracy needed to quantify surface sources and sinks on regional scales. As currently planned, OCO will be launched in late 2008. It will fly in a 705-km, nearpolar sun-synchronous orbit that will sample the sunlit hemisphere every 16 days for up to two years.

OCO carries a single instrument with three high resolution grating spectrometers designed to measure the absorption of reflected sunlight by CO_2 and molecular oxygen (O_2) bands at near-infrared wavelengths. Spectra of the CO_2 bands near 1.61 and 2.06 microns provide surface-weighted estimates of the CO_2 column abundance. Bore-sighted spectra in the 0.76 -micron O_2 A-band provide precise estimates of surface pressure as well as constraints on clouds, aerosols, and the surface. The CO_2/O_2 soundings are analyzed to yield estimates of the columnaveraged CO_2 dry air mole fraction, XCO_2. A small surface footprint (<3 km^2 at nadir) is used to reduce XCO_2 biases associated with spatial variations in clouds and surface topography. Thousands of soundings are collected on regional scales each month. A comprehensive ground-based validation program is used to assess random errors and minimize biases in the XCO_2 product to ensure precisions of 0.3 to 0.5% (1 to 2 ppm) on regional scales (1000 km by 1000 km) at monthly intervals.

While OCO is an exploratory Earth System Science Pathfinder (ESSP) mission designed for a 2-year lifetime, its measurements can be combined with data from the surface CO_2 monitoring networks to improve our understanding of the processes that regulate atmospheric CO_2 sources and sinks over the annual cycle. This information could dramatically improve predictions of future atmospheric CO_2 increases. OCO will also validate technologies and analysis techniques that would be well suited for future long-term greenhouse gas monitoring missions.

P-CA2.9

Methane Emissions from Natural Wetlands in the United States: Satellite-Derived Estimation Based on Ecosystem Carbon Cycling

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Wetlands are an important natural source of methane to the atmosphere. The amounts of methane emitted from inundated ecosystems in the United States can vary greatly from area to area. Seasonal temperature and carbon content of soils are principal controlling factors. To calculate the effect of wetlands (and their potential conversion to other land uses) on global greenhouse gas emissions, information on area covered by various wetland types is needed, along with verified projections of spatial variation in net methane emissions. Both of these variables are poorly known, and estimates are largely unavailable at the country level. Nationwide satellite data sets for the U.S. have been combined with ecosystem model predictions of monthly net carbon exchange with the atmosphere to produce the first detailed mapping of methane fluxes from natural wetlands on a monthly and annual basis.

P-CA2.10

Carbon Budgets for Ecosystems of the Continental United States

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NASA satellite remote sensing and vegetation-soil modeling are being used to estimate the carbon balance for ecosystems in the continental United States. To support decision making for carbon management, we report on the CQUEST (Carbon Query and Evaluation Support Tools) application, with spatially detailed (< 10 km resolution) terrestrial carbon budgets for regions of U.S. in the 1980s and 1990s. Surface soils and dead woody litter are by far the largest storage pools for carbon across the country, representing more than 35 Pg C with residence times of 25 years or less. The Southeast, Rocky Mountain, and Pacific Northwest regions of the country store the largest pools of ecosystem carbon. Although net primary production was estimated to increase on a nationwide basis during the 1990s to nearly 3.5 Pg C per year, the net terrestrial sink in U.S. ecosystems did not exceed 0.05 Pg C per year between 1982 and 1997. Net ecosystem carbon sinks for the nation were typically small, relative to fossil fuel-related carbon emissions in the U.S. on an annual basis, which makes decision making to protect large surface soil carbon and woody litter pools crucial for maintaining the national carbon balance under future climate shifts.

P-CA2.11

The U.S.-China Carbon Consortium (USCCC) and Its Contribution to Global Change Studies

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The U.S.-China Carbon Consortium (USCCC) was established in 2003 in Beijing as a collaborative consortium between American and Chinese institutions that have interests in studying the role of managed ecosystems in the global carbon and water cycles, including the Southern Global Change Program of the USDA Forest Service (SGCP), the University of Toledo, North Carolina State University, the Institute of Botany at Chinese Academy of Sciences, Fudan University, Beijing Forestry University, the Chinese Academy of Forestry, Nanjing University, and the Meteorology Administration of China.

The overall goal is to develop a network of study sites sponsored by the above institutions in hope that data and results will be shared so that synthesis can be made at inter-continental scale to assess the importance of human influences on carbon and water fluxes in the changing climate. USCCC, governed by a steering committee, will adopt the data sharing policy of Long-Term Ecological Research Networks (LTER) for our future research. The data will be open to all the partitioning members through project Web pages with permission of the institution. Eddy-covariance flux towers are the central infrastructure of all USCCC sites (18 in China and 11 in the eastern U.S.).

Our central hypothesis is that human disturbances increase the variability of C sequestration and water cycle of a landscape in time and space primarily via influence of the landscape structure and composition that directly affect the underlying mechanisms. Further, we hypothesize that the human disturbance regimes in the U.S. and China are significantly different, suggesting that models predicting carbon, water and energy are different. Data from several USCCC sites in northern China are members of NASA's NEESPI team (LCLUC Program) and Moisture Isotopes in the Biosphere and Atmosphere (MIBA) of IAEA. Data will be folded into the GOFC/GOLD and NEESPI programs.

P-CA2.12

Urban and Regional Carbon Management: Comparative Framework of the Global Carbon Project

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The Global Carbon Project promotes global carbon cycle research that combines natural and social sciences for policy-relevant sustainability science. The "global" becomes place-based at urban and regional scales for carbon management. The GCP's Urban and Regional Carbon Management (URCM) initiative is a comparative, integrated scientific approach to place-based carbon budgets and management strategies across spatial and temporal scales. Three spatial scales are prominent: urban, regional, and cities-in-regions. By understanding the carbon legacies of various development pathways, the URCM aims to identify key opportunities for de-carbonized futures in communities around the world. The GCP is a joint program under the Earth System Science Partnership of the International Geosphere/Biosphere Program, the International Human Dimensions Programme, the World Climate Research Program, and DIVERSITAS.

P-CA2.13

A Bayesian Synthesis Inversion of Carbon Cycle Observations: How Do Observations Reduce Uncertainties About Future Sinks?

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Current predictions of CO_2 sinks vary widely due to uncertainties about key feedback mechanisms (e.g., the potential increase in global respiration in response to warming). A sound characterization of these prediction uncertainties is crucial for the design of economically efficient carbon management strategies. Current predictions are typically based on a few model scenarios without a probabilistic assessment. Here we use a mechanistically sound and statistically tractable model of the global carbon cycle to (i) assimilate historical observations of atmospheric CO_2 concentrations and oceanic CO_2 fluxes, (ii) derive probabilistic predictions of future CO_2 concentrations and fluxes, and (iii) assess the power of different observing systems to reduce predictive uncertainties.

Specifically, we address three key questions: (i) Given current observation systems and prior information regarding carbon cycle parameters, what are the confidence limits of the future sink strength for a CO_2 stabilization objective? (ii) How does the observed (but typically neglected) autocorrelation in observations of CO_2 mixing ratios affect these predictions, and (iii) What are the abilities of candidate carbon cycle observation systems to reduce the predictive uncertainty? We address these questions using a Bayesian synthesis inversion of a simple coupled climate/carbon cycle model with historical observations from 1850 to 2000. Assimilated observations include atmospheric CO_2 concentration data from the Law Dome ice core (1850-1959) and Mauna Loa (1960-2000) as well as observations of oceanic fluxes derived from hydrographic tracers. We estimate key model parameters representing the temperature sensitivity of global respiration, carbon fertilization, ocean thermocline diffusivity, and the temperature sensitivity of net primary productivity. The probability density functions of these parameters are used to estimate the parametric uncertainty of the predicted strength of the carbon sink. We use this framework evaluate the ability of candidate carbon cycle observation systems to reduce parametric prediction uncertainty. In particular, we focus on observations of terrestrial fluxes in order to demonstrate the possible value of the FLUXNET eddy covariance tower network in reducing these uncertainties.

P-CA2.14

Methodology and Cost of Evaluating Soil Carbon Stocks in a 2-m Soil Profile

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Estimates of world soil carbon stocks are incomplete and inadequate, because most of them are based on actual soil data down to 1 m depth only and obtained by outdated methods. Therefore, call for more research in climate change science is justified. This study examines different methodology and costs associated with analyses to improve soil carbon stock estimates using experimental data from Mollisol, one of the most productive soils in the world. Availability of laboratories capable of these analyses and their prices are examined within United States of America using Geographic Information Systems (GIS). Given the dynamic nature of soil carbon reserves due to human influence, there is a need to determine time intervals for re-assessment of soil carbon stocks.

P-CA2.15

Carbon-Climate System Feedbacks to Natural and Anthropogenic Climate Change

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A new generation of climate-carbon cycle models is being used to explore the responses and feedbacks of biogeochemistry to climate change. We highlight results from a stable, 1,000-year control simulation and transient experiments (1820-2100) using the Community Climate System Model (CSM 1.4 Carbon). Key findings include: modulation of terrestrial variability and climate change response via soil moisture; oceanic damping (20-25%) of atmospheric CO_2 variability at low frequencies (> 20 years); inverse relationship between carbon sink efficiency and fossil fuel emissions; and decreasing in land and ocean carbon storage under climate warming, amplifying climate change.

Poster Abstracts

P-C01.1

Space Based Data and Technology Applied to Gulf Coast Geodesy

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Understanding the combined effects of subsidence, sea level rise, storm surges and flooding on the very low lying Gulf Coast of the United States has major public safety, infrastructure, economic, and homeland security implications. Coastal subsidence has long been held to be a major factor behind loss of Gulf Coast wetlands, particularly those within the Mississippi Delta in Louisiana. Subsidence has also rendered “obsolete and inaccurate” the National Spatial Reference System in Louisiana and other coastal areas along the northern Gulf of Mexico (NOAA Report to Congress, 2001). This means that critical infrastructure, particularly hurricane evacuation roads, storm surge protection levees, and oil and gas facilities, are potentially at risk. Furthermore, because the landscape (and evacuation roads and levees) continues to subside, emergency personnel do not have accurate information. Recent work by Shinkle and Dokka (2004) has disclosed that the elevation situation is worse than previously understood; the entire coast may be at significant risk due to poor elevation control. Previous releveling surveys incorrectly assumed that local starting benchmarks were stable. In contrast, vertical velocities presented in Shinkle and Dokka (2004) were related to the North American Vertical Datum of 1988 further validated by water level gauges and GPS measurements. These well constrained measurements show recent subsidence has occurred 2 to 5 times faster than previous estimates and is not restricted to just wetlands, but includes coastal communities where over 10 million people live. Additional subsidence rates from GPS and InSAR show that subsidence rates are not uniform, adding to the complexity of the picture. From a longer term perspective, the new data indicates that the area of subsidence extends far beyond the coast, suggesting that crustal-scale processes such as loading by recent sedimentation is a contributor to subsidence and resultant land loss. In order to fully understand and predict future subsidence accurately, it is necessary to understand the contributions from sediment loading, compaction, growth faulting, and fluid withdrawal. This requires an integrated modeling and measurement approach using surface and space-based data. We will present our recent results and discuss future plans.

P-C01.2

Impact of Sea-Level Rise on the Mid- and Upper-Atlantic Coast

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Previous studies suggest that by the end of this century climate change could raise sea-level by 2 feet on average, ranging from 1.5 to 3.5 feet, for the Atlantic coastal region. The range reflects, in part, the variability in subsidence throughout the region. For the Consortium for Atlantic Regional Assessment (CARA), we first quantify this variability by removing the rate of global sea-level rise from the observed sea-level rise at water level monitoring stations throughout the region. We then make projections of future sea-level using the estimated subsidence rate and projections of global sea-level from seven climate models run under two greenhouse gas emission scenarios. In order to make these projections more useful for decision makers, they need to be translated into the area affected by sea-level rise. In the next step, we use GIS models to combine topographic, land use and census data to show the potential impact of projected sea-level rise in each of the 85 coastal counties from Massachusetts to Virginia. Five elevation zones are mapped along with current open water: 1) land areas below 0 feet; 2) areas 0 to 3 feet; 3) areas 3 to 6 feet; 4) areas 6 to 9 feet; and 5) areas above 9 feet. Zones 1 and 2 are likely to be completely inundated with future sea-level rise. Zones 3 and 4 are likely to become future tidal land. Zone 5 is considered safe from sea-level rise. Such delineation allows flexibility in using these maps to accommodate uncertainties in sea-level rise projections as well as local variations in tidal range and sea-level rise. For each county, a map shows these elevation zones; quantities of land area in different zones are calculated and presented in tables. In addition, the map of elevation zones is overlaid with land use and 2000 Census block information to calculate the breakdown of different land use types and the number of people living in these elevation zones. All of the information (maps and tables) is provided to the stakeholders through the CARA website, so that they can explore interactively the maps showing areas at risk of sea-level rise and other related information. CARA, a research and outreach effort funded by EPA, provides scientific information and tools through internet resources that government agencies, communities, citizens, businesses and other stakeholders can use for exploring and adapting to potential impacts from changes in land use and climate in the mid- and upper-Atlantic region.

P-C01.3

An End-User Defined Coastal Climatology Product for Recreation and Tourism in Southeastern North Carolina

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The objective of this project was to develop a test coastal climatology product for recreation and tourism end-users in southeastern North Carolina. The product was designed so that it can offer guidance and serve as a model to the Coastal Services Center (CSC) and National Climatic Data Center (NCDC) of NOAA for further development of climatology products useful to coastal managers across the southeastern United States. Needs assessment interviews were administered to 125 recreation and tourism managers and 330 recreation and tourism participants across the study area and results indicated that recreation and tourism managers and participants place a high value on marine and weather information. However, it should be noted that few, if any, of the interviewees use marine and/or weather information on the climatological time scale (month or longer). The variables most frequently required by interviewees was hurricane information, air temperature, rain probability, water temperature, and wave height. Interview results also indicate managers and participants rely heavily upon television, Web sites, and radio for this information. Based upon these interviews and a web site "focus group," it was decided the test product developed for the project was to be a simple web site that provides coastal climatology information and also serves as an educational resource which places local scale real-time observations within a climatological framework. The test product (http://www.cormp.org/climate/) consists of one "dynamic" page that displays near real-time observations from CORMP observation stations in a climatological context, and four static pages that provide a description of Onslow Bay climate, climate predictions for the United States, hurricane information for Onslow Bay, and contact information for the PIs and CORMP Outreach. The web site was also constructed to incorporate the cross-cutting issues outlined by Janis and Gamble (2004) as important to the development of effective and useful products for coastal managers from Virginia to Florida. Specifically, the product is a user-defined, collectively designed coastal climatology that utilizes local-scale observations and integrates weather, marine, and climate information across consistent spatial and temporal resolutions. The product also facilitates interaction and follow-up between end-users, the public, and scientists.

P-C01.4

Global Climate Change Impacts on Coastal Infrastructure Services

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Consequences of global climate change (GCC) potentially have devastating impacts on the ability of infrastructure to deliver services vital to public health and the economy. One GCC consequence is increased temperature that directly can affect the structural integrity of materials used in infrastructure facilities. Many common materials such as steel and concrete normally have limited tolerances to large, prolonged temperature changes beyond a certain range, and can weaken or collapse under such stress. Another GCC consequence is flooding from rising sea levels, thermal expansion of water, and precipitation, since many infrastructure facilities have traditionally been built in low lying areas prone to flooding (Zimmerman 1996, 2003 with FEMA and USACE data). Catastrophic effects of Hurricane Katrina attest to this.

Scenarios portraying vulnerabilities to infrastructure services from increased heat and flooding are presented, with choices available to decision-makers to reduce vulnerabilities through facility location, design, and usage. Measures for infrastructure planning, siting, design, construction, and operational practices in U.S. urbanized coastal areas that address GCC vulnerabilities are examined, including cases of adaptations to heat and flooding by new and pending large construction projects. This work covers transportation, water, energy and telecommunications. In addition, interdependencies within and among infrastructure that contribute to vulnerabilities are taken into account. Interdependencies include multiple facilities co-located or functionally interdependent; when one infrastructure facility fails, others also fail. Practices that inevitably pose vulnerabilities are identified for decision-makers as areas where new technological innovations are needed. This work builds on the author's previous work cited below.

Zimmerman, R. "Global Climate Change and Transportation Infrastructure: Lessons from the New York Area," in *The Potential Impacts of Climate Change on Transportation: Workshop Summary and Proceedings*, Washington, DC: U.S. DOT, 2003, pp. 91-101.

Zimmerman, R. and M. Cusker, "Institutional Decision-making," Chapter 9, 10 in *Climate Change and a Global City: The Potential Consequences of Climate Variability and Change.* Metro East Coast, C. Rosenzweig and W. D. Solecki, eds. NY, NY: Columbia Earth Institute and Goddard Institute of Space Studies, 2001, pp. 9-1 to 9-25; A11-A17.

Zimmerman, R. "Global Warming, Infrastructure, and Land Use in the Metropolitan New York Area: Prevention and Response," in *The Baked Apple? Metropolitan New York in the Greenhouse, Douglas Hill*, ed. NY, NY: NY Academy of Sciences, 1996. Pp. 57-83.

P-C01.5

Which Uncertainties Matter for Decision-Making? Development of an Integrative Decision-Centered Screening Tool with an Application to Coastal Management in California

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Science that aims to support decision-making must by useful, relevant, credible, and legitimate. Research does not meet these requirements naturally or easily and instead requires active collaboration of scientists and decision-makers to become truly decision-relevant. In the context of climate change,

scientific uncertainty can make finding this balance between what decision-makers need and what scientists can credibly provide even more challenging. It is critically important therefore that scientists clearly understand decision needs and effectively communicate the uncertainties associated with the information to practitioners. This paper presents a process model of how scientists and decision-makers can ascertain the decision-needs of the practitioner and decide on necessary analyses. It specifically helps to discern what type of information decision-makers may need about uncertainty associated with the provided scientific information. As such this Decision-Uncertainty Screening Tool (DUST) is educational for the scientists not yet familiar with working with a particular practitioner or in a specific decision context. It also helps practitioners who need to understand what kind of decision support science can realistically provide. The tool further helps to efficiently identify the (uncertainty) analyses that are actually needed to be useful in particular decisions. This systematic approach of determining where and when the decision-making environment is particularly sensitive to uncertainty in the information provided is currently being tested in a case study of coastal management in California. What scientific information do coastal managers actually need to address the potential impacts of climate change-driven sea-level rise? The paper will present first results of this test in an empirical setting and discuss lessons learned. The ultimate goal is that DUST – once fully tested and refined – will give scientists and decision-makers a procedure to identify those instances where science can most effectively support decision-making.

P-C01.6

The Consortium for Atlantic Regional Assessment: Bringing Climate and Land Use Change Information to Local and Regional Decision Makers

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The Consortium for Atlantic Regional Assessment (CARA) is a collaborative effort between several universities to bring scientific information on climate change and land use change to communities and stakeholders within the mid-Atlantic region. The data and tools provided on the CARA website can help stakeholders and decision-makers understand how potential changes in climate and land use may impact water quality and quantity, ecosystems, public health, food supply, transportation, storms and floods, and energy supply in their region or locality. Decision-makers can use this information to take advantage of positive consequences that may result from climate and land use change as well as adapt to negative ones. The CARA website showcases each of these sectors with interactive tools and tutorials – allowing the user to gain knowledge specific to the conditions of a given area. The importance of climate and land use change knowledge on the local and regional scales is emphasized by four case study sites throughout the CARA region (Cape Cod, MA; Cape May, NJ; Adirondack Park, NY, and Hampton Roads, VA). CARA has developed a website that serves several purposes:

1) Provides local and regional stakeholders and decision-makers with useful information for making choices in the context of potential changes in climate or land use patterns in their area
2) Produces interactive tools and tutorials for stakeholders and decision makers to explore historical data and future projections
3) Illustrates the utility of this information and tools through case studies.

The CARA website has metamorphosed through several iterations in a conscious effort to present the tools and information to prospective users effectively and concisely. This poster illustrates the current layout of the site as well as offering examples of the types of data and tools that it presents.

P-C02.1

Choice Modeling Tools to Inform Climate Change Decision-Making: A Case Study on Public Preferences for Coastal Wetland Restoration

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Our poster highlights the production of information in support of decision making for climate change and provides a case study and overview of a powerful social science tool for informing decision making regarding climate change policy. The case study addresses policies for large-scale restoration of Great Lakes coastal wetlands. Coastal wetlands provide critical ecosystem services that affect human well being including the provision of recreation, support of fish and wildlife game populations, and numerous other ecological functions. Although coastal wetlands are adapted to and depend on some variability in water levels, changes in water levels that are expected to occur in the Great Lakes due to climate change will have profound impacts on Great Lakes coastal wetlands. The case study research estimated public preferences and support for policies and programs aimed at large-scale restoration of Great Lakes coastal wetland ecosystems. Ecological restoration decisions in coastal zones are critically dependent on climate change policy as anticipated water level changes directly affect coastal wetlands.

The case study research sought to learn public preferences for different preservation and restoration programs for Great Lakes coastal wetlands. The reported results are based on data from a mail survey of a random sample of Michigan residents. The survey included general questions and information about Great Lakes wetlands. The survey then gave respondents a stated choice question about wetland programs that asks respondents to make trade-offs between alternative programs with different program attributes such as the environmental services to be preserved or restored, different levels of preservation and restoration activities, and the types of property acquisition mechanisms. Statistical results reveal significant public preferences for biodiversity services of coastal wetlands as well as significant preferences for more secure, long-term property acquisition methods.

The case study demonstrates the use of multiattribute choice modeling to elicit and quantify public support and preferences for ecological restoration programs that differ in their characteristics. The choice modeling methodology has wide application in the area of climate change as a method for eliciting and quantifying public preferences for alternative policy and mitigation scenarios. The resulting preference information can be used to craft policies that maximize public support or to identify critical areas where educational efforts might be well targeted to better inform public preferences.

P-C02.2

Sea Level Rise and Potential Change in Coastal Bird Habitat in New Jersey, USA

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The consequences of global climate change are expected to intensify in the 21st century and beyond resulting in accelerating rates sea level rise. The effect will be the inundation, flooding, erosion and increasing salinity of shorelines, barrier islands and low-lying mainland areas. This will cause changes in coastal bird habitat, including reductions and alternations in wetlands, and inter-tidal and beach areas. This study provides an illustration of the effects of sea level rise on four globally important bird areas in New Jersey, USA. The study predicts the ability of these bird areas to support a variety of coast dependent bird species at current population levels given sea level rise. The results indicate, based on the models, that the extent of the habitat change will likely be unable to sustain present bird populations and potentially even particular bird species, especially those currently endangered, threatened or in decline.

P-C02.3

Prediction of Ecological Effects of Sea Level Rise in North Carolina through Coupled Hydrodynamic, Digital Elevation, and Habitat Models

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The Ecological Effects of Sea Level Rise research program is designed to help managers prepare for changes in coastal ecosystems due to sea level rise (SLR) by providing an ecological prediction that utilizes modeling and mapping tools. The first priority in developing ecological predictions is to model the hydrodynamic response of the system. A Coastal Flooding Model (CFM) has been developed for North Carolina by combining a high-resolution hydrodynamic model with continuous bathymetric/topographic elevation data. The CFM computes tidal response, regional synoptic wind event circulation, and hurricane storm surge propagation to study changes in these events due to SLR. Integrated into the CFM is a high-resolution continuous bathymetric/ topographic Digital Elevation Model (DEM). LIDAR (LIght Detection And Ranging) data providing topographic elevation relative to NAVD 88 were combined with bathymetric sounding data relative to NAVD 88 to construct the continuous DEM, which is important for accurately predicting rising water levels. The bathymetric data were transformed from local tidal datums to NAVD 88 through use of the vertical transformation tool VDatum, which enables conversion between tidal, orthometric, and ellipsoidal datums by combining hydrodynamic and geoid models with benchmark data. Ecological predictions will be made by coupling the CFM with ecological habitat models to determine habitat fate and landscape change due to SLR.

P-C02.4

Predicting the Persistence of Coastal Wetlands to Global Change Effects

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Global average eustatic sea level is projected to rise under all emission scenarios used by the Intergovernmental Panel on Climate Change (IPCC) in their climate models with most model scenarios indicating an increase of 30-50 cm relative to 1990 levels. Similar model scenarios have been used in combination with coastal elevation data to estimate that a 1 meter rise in sea level could reduce coastal wetlands in the United States by 26 to 66 percent. These low-lying lands provide important habitat for plant and animal species and over US trillion in ecosystem services worldwide. LIDAR imagery or detailed elevation surveys have historically been combined with projected rates of sea level rise to assess the vulnerability of coastal wetlands. However, this approach has not included the potential for coastal wetlands to respond to increases in sea-level rise. We used new technology to understand the linkages and feedback effects that control habitat stability of coastal wetlands, and the specific biological and physical processes that determine how wetland surface elevations respond to changes in relative sea level. We illustrate this approach with work from sites in the Mid-Atlantic and provide a research strategy used to develop a predictive capacity to forecast future responses of coastal wetlands to changes in external forcing functions.

P-C02.5

Studies of Climate-Driven Changes in Lake Levels Assist in Decision Making in the Great Lakes Region

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The effects of climate change on Great Lakes wetlands are both directly and indirectly tied to climate-driven changes in lake levels. We conducted studies to evaluate those linkages and their effects on wetland plant communities, as they occurred in the past, as a means of predicting potential future responses to climate change. The studies made use of chronosequences of beach ridges and wetlands that form in strandplains in large embayments along the shores of the lakes. Each beach ridge was formed at the end of a high lake-level period corresponding to a short-term cooling event (about every 33 years in lakes Michigan and Huron). High lake levels also occurred in longer quasi-periodic cycles (about 160 years), with the short-term cycles encompassed within them. These longer-term events clearly match records of past climate change from other sources and represent a proxy for climate change in the upper Great Lakes region over the past 4700 years. These findings have had a profound effect on decision-making in the Great Lakes region. Studies conducted under the International Joint Commission's Lake Ontario-St. Lawrence River Reference Study to develop a new water-level-regulation plan for Lake Ontario have recognized these patterns and their role in development and maintenance of wetland plant communities. The results also portend future water supplies to Lake Ontario that affect plans for regulation. An International Joint Commission study to review the regulation plan for Lake Superior is also being considered; similar climate-change studies have produced a long-term lake-level record specific to Lake Superior that will be instrumental in evaluating environmental components of that study, as well as foretelling what the future may hold with respect to all other study components. In addition to predicting effects of future climate change on Great Lakes wetlands, study results have also been used to reevaluate rates of rebound of the Earth's crust in the upper Great Lakes region following melting of Wisconsinin glaciers, to reevaluate the separation of Lake Superior from lakes Michigan-Huron more than a millennia ago, and to develop an understanding of dune development processes along the shores of the lakes that are critical to land managers.

P-C03.1

Decision Support Tools for Coral Reef Management under Changing Climates

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This presentation will address the incorporation of climate change information into coral reef and related coastal ecosystem management decision support tools. The project, which is being carried out by climate information users from the academic community under funding from EPA's Global Change Research Program, focuses on improving scientific and technological support for coral reef management in the context of climate change. As such, this work supports the U.S. Climate Change Science Program's Goal 4 evaluation of "adaptation options for climate-sensitive ecosystems and resources."

Coral reef ecosystems support hundreds of millions of people and are essential to the economies of many states and nations. A myriad of anthropogenic stressors have resulted in a global decline in coral reef ecological health and integrity, with a consequent loss of essential ecological services. Climate change is expected to have severe consequences for coral reefs, compounding the negative effects of human activities. In addition to direct impacts on coral growth via warming seas and changing seawater chemistry, climate change will impact coral reefs through increasing storm damage, altered current patterns, rising sea-levels, increasing land runoff, and changes in human use patterns. In order to ensure that coral reefs are given the best possible chances to persist in the face of climate change, it is crucial that adverse human impacts be reduced through knowledge-based, participatory resource management. Additionally, spatially-explicit management should be adjusted to enhance resilience to, and recovery from, climate-related stresses and perturbations—as in providing special protection to climate change tolerant species and sources of larvae.

We have developed a decision support tool, Data Navigator South Florida, which provides user-friendly public access to hundreds of spatially-explicit data sets via an advanced, online GIS interface with layer presentation based on decision trees. Climate-related, satellite-based information is automatically updated via third-party websites. Other data entry will be increasingly automated as online climate change simulators, improved ocean observing systems, and real-time hydrodynamic models become operable.

We have also developed a series of simulation models as steps toward incorporating scenario-testing capabilities into the tool. These include agent-based models of coral disease, 3-dimensional seaweed dynamics, coral reef food-webs, ecological resilience, and coupled human-environment interactions. The integrated simulator under development will permit users to input combinations of human and climate change stressors, providing ranges of potential ecological and socioeconomic consequences in spatially explicit form that can be analyzed within the context of extant information in the Data Navigator.

P-C03.2

Coupling Remote Sensing and In-Situ Data to Derive a Calcification Index for Coral Reef Ecosystems

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Mounting evidence suggests that as a consequence of rising atmospheric CO_2, profound pH changes in the surface layers of the world's oceans are occurring. A concurrent decrease in the concentration of carbonate ion has resulted in reduced saturation states with respect to the carbonate minerals that serve as substrates to coral reef communities. Such changes in ocean chemistry are expected to become increasingly evident in the coming decades. Experimental observations show a strong correlation between the calcification rate of carbonate secreting organisms and saturation state leading many investigators to conclude that calcification rates could significantly decrease by the middle of the 21st century. Coral reef ecosystems may be subject to enhanced biological and mechanical erosion as a consequence and would be unable to sustain sufficient extension rates to accommodate rising sea level. The mission of NOAA's Coral Reef Watch Program is to utilize remote sensing and in-situ tools for near real-time and long term monitoring, modeling and reporting of physical environmental conditions of coral reef ecosystems; assisting in the management, study and assessment of impacts of environmental change on coral reef ecosystems. Within the purview of this mission, Coral Reef Watch is seeking to monitor the long term response of coral reef ecosystems to changing carbon chemistry by coupling a multitude of advanced tools including remote sensing, ships-of-oportunity and moored stations. The production of CO_2 as a byproduct of calcification results in elevated aqueous CO_2 concentrations relative to surrounding waters. The reef water to offshore difference in sea surface carbon dioxide partial pressure is indicative of the system-level metabolic performance of a coral reef ecosystem. Based on this quantity an index is proposed that will provide a qualitative assessment of the overall calcification performance at a reef system. Algorithms are currently being derived that correlate shipboard measurements of p CO_2 in the Caribbean Sea to collocated satellite products including sea surface temperature and ocean color. Such algorithms will be used to generate a near real-time regional p CO_2 field to which continuous in-situ near-reef CO_2 measurements can be compared.

P-C03.3

Climate and Ecosystem Research to Advance Fisheries Management

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Alaskan fisheries account for approximately 50% of the U.S. commercial fishery landings with a landed value of approximately $1.5 billion each year. Global climate models predict climate change and variability will be most severe at high latitudes and there are many indications that environmental conditions are already changing in these regions. The need for resource management to account for this forcing mechanism is clear as changes in physical forcing in the region may drastically change the structure and functioning of the marine ecosystem and cause profound geographic shifts in species distributions.

An ecosystem approach to management requires understanding how climate fluctuations affect the ecosystem. The North Pacific Climate Regimes and Ecosystem Productivity (NPCREP) study is building this understanding for the eastern Bering Sea and Gulf of Alaska by investigating the physical and biological controls on the ecosystems and how these are affected by climate variability and change. A combination of retrospective, monitoring, process and modeling studies are advancing the understanding of the impacts of climate on the fisheries in the region. NPCREP is establishing a monitoring network, consisting of satellite observations, moorings, drifters and shipboard surveys, which utilizes existing observations and supplements these with measurements critical to the success of the project. Coupling these observations with information from NPCREP retrospective and process studies generates the necessary foundation for understanding climate-ecosystem relationships. Through the increased understanding being obtained about the impacts of climate variability and change on the fisheries in the eastern Bering Sea and Gulf of Alaska, NPCREP is developing indicators of climate impacts on marine ecosystems and models to predict the probable consequences of global climate change on the eastern Bering Sea and Gulf of Alaska. These products are delivered to fisheries managers at the North Pacific Fishery Management Council so that climate variability and change can be incorporated into the management decisions affecting the living marine resources in these regions.

WP-WE1.1

Pacific ENSO Applications Center (PEAC): The First Decade

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This presentation will provide insights derived from a decade of experience producing and using seasonal climate forecasts American Flag and U.S.-Affiliated Pacific Islands.[1] An ongoing review of the first decade of operations of the Pacific ENSO Applications Center (PEAC) is providing guidelines for the design of future climate services[2] in the region and helping to document how climate information is supporting adaptive management and planning capabilities in the jurisdictions served by PEAC. The author was the initial Federal program manager for the PEAC research pilot project and is now leading Pacific regional climate vulnerability assessment and risk management programs at the East-West Center in Honolulu, HI, including the review of PEAC operations that will serve as the focus of this presentation.

The PEAC review is enabling scientists, decision-makers and funding agencies to develop a sense of how well this program is currently addressing some of the general design principles highlighted in the 1999 National Research Council (NRC) report entitled *Making Climate Forecasts Matter* including issues related to:

- Successfully matching climate information messages with the needs of specific target groups;
- Consideration of a comprehensive information delivery system;
- Using participatory approaches to enhance information delivery (and application); and
- Combining climate information with a variety of intervention approaches.

Although work on the PEAC review is ongoing, a few key "lessons learned" about climate forecasting and services are emerging:

- **Use a problem-focused (vs. forecast focused) approach** and **Strive for a climate information system** addressing multiple timescales rather than solely an "event-based" early warning system;
- **Early and continuous partnership and collaboration with users is essential**; utilize a ***collaborative, participatory process*** involving both users and providers of climate information and services
- **Build on existing and trusted information brokers**; recognize the importance of local and traditional knowledge and practices as well as non-governmental players
- **Recognize the need for an integrated program of observations, monitoring, forecasting, assessment, education, dialogue and applications**
- F**acilitate proactive decision-making** through information and services that support ***iterative, reflective, flexible and adaptive approaches***
- **Climate risk management –** ***and the climate information systems that support it*** **– should be set in a sustainable development context** which enables communities, businesses and governments to respond to today's variability, adapt to long-term change and mainstream the use of climate information to support community development and economic planning.

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[1]The American Flag Pacific Islands comprise the State of Hawaii, Guam, American Samoa and the Commonwealth of the Northern Mariana Islands and the U.S.-affiliated Pacific Islands comprise the Republic of the Marshall Islands, the Republic of Palau and the Federated States of Micronesia.

[2]James Weyman, Pacific Region Climate Services Focal Point for the NWS Pacific Region, indicated at a June 2004 workshop conducted as part of the PEAC review that the findings and recommendations for the review will provide a "roadmap for the future of PEAC and climate services in the Pacific region."

P-WE1.2

Climate Change—A Looming Challenge for California: Applying State and Federal Science to Inform Decision Makers

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To inform California decision makers of challenges in the next few-several decades that are likely to be imposed by climate changes, the State has instated a California Climate Change Center (CCCC), which includes physical climate scientists and a collective of economists and other social scientists. The CCCC is working closely with the NOAA RISA program through the California Applications Program (CAP); for background see http://meteora.ucsd.edu/cap/ and other CCSP presentations by G. Franco, A. Westerling and K. Redmond). In order to satisfy needs for information ranging from local to global scales, CCCC and CAP are striving to improve the State's observational capacity as well as exercising a hierarchy of coupled, atmospheric, hydrologic and other models, to elucidate possible and probable future climate in the region and its impacts.

In one way or another, many of the State's climate issues are related to water. California is vulnerable to changes in climate owing to a volatile climate background, its dependence on snowpack and its exposure to coastal sea level rises. Climate change impacts in California are strongly oriented around water issues—water is vital for ecosystems, agriculture and industrial and domestic consumers. California's water resources are already heavily utilized and climate change is an additional stress. In California, snow provides an important additional reservoir that historically has been equivalent to almost half of the water stored in the "built" reservoirs, capturing winter storm precipitation and releasing it relatively gradually later in spring and summer when the threat of storms has diminished and demand is higher. Climate warming over the last half century has already impacted spring snowpack in the region, with losses of approximately 11% over the West, and advances in spring snowmelt timing of one-four weeks. Projected warming, adding to the ~1ºC increase seen in the recent historical period, would have a substantial impact on snow accumulation in the Sierra Nevada, a relatively warm mountain range which has a high sensitivity to changes in temperature. Hydrologic models project that such a warming would cause more rain, less snow, and earlier snowmelt, so that, by the middle of the 21st century, spring snowpack would be diminished by 25 to 40%, depending on greenhouse gas emissions and the resultant regional warming. On top of this, as with other western states, natural climate variability in California is large, so that any given year is not guaranteed to provide the "normal" supply. There is a propensity for multi-year droughts, as we know from our instrumental record as well as from paleoclimate evidence. Longer summers and higher temperatures will likely amplify the demand for water, not only by humans, but by natural ecosystems and agricultural settings, and would increase wildfire threats. Ironically, the incidence of floods is also likely to increase as rain/snow boundaries in mountain catchments reach higher altitudes. California has about 1,500 km of coastline and several coastal aquifers which are susceptible to sea water intrusion. Also, because much of California's precipitation falls in the north and most of the consumption of water occurs to the south, much of the State's water system is conveyed through the upper reaches of the San Francisco Bay estuary, at the confluence of the Sacramento and San Joaquin Rivers. Rising sea levels would threaten this fresh water supply as well as rich ecosystems and levied farm land in the San Francisco Bay Delta.

P-WE1.3

The Western Water Assessment: Integrated Sciences for Decision Support

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The NOAA/CIRES Western Water Assessment is centered at the University of Colorado, Boulder. The Interior West (Colorado Plateau and its runoff basins) contains the primary headwaters for water supply to major regions, including the Colorado Front Range, the arid Southwest, California, and the western Great Plains. The Assessment was developed to address the issues surrounding climate variability and change, and their impacts on water quality and quantity in the Interior West.

The initial projects were chosen with thought given to climate variability impacts on water supply and ecosystems, water demand trends, and system vulnerability. The first case study in the "Western Water Assessment" was on the South Platte Basin. Partners included the Bureau of Reclamation and various Conservancy Districts. The team's approach to assessing regional change and vulnerability on the South Platte includes the following areas of emphases: climate impacts on water supply and demand zones in the South Platte (where 30% of water used is transferred from the West Slope); investigating current uses of climate information and user needs; development of tailored ENSO forecasts for improving seasonal water supply planning; creation of short-term streamflow forecasts for specific management applications (e.g. flow augmentation requirements for the maintenance of endangered fish habitat); and implications of climate variability for low flows and dilution of discharges from point sources. More recently interest has been generated in the use of paleoclimatic data in long-term water resources assessments and projections especially in the Front Range.

WWA has a very wide diversity of partnerships, loosely grouped into three categories: (1) climate-information providers (National Weather Service including river forecast centers, National Interagency Fire Center, Colorado Drought Task Force), (2) operational water managers (e.g., municipal water suppliers and federal reservoir managers), and (3) planning and policy interests (e.g., legislators, county commissioners, major interest groups, and the general public). With very few exceptions, these interests all share a focus on water resources in the interior West. This diversity of stakeholders necessitates a mixed portfolio of products and processes. As these have evolved over time so has the structure and dynamics of the WWA team itself. Its evolution provides valuable lessons for the design of interdisciplinary teams working under a decision support framework.

P-WE1.4

Effecting Systemic Change in Climate Information Delivery and Decision Support

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The U.S. national investment in remote sensing systems, supercomputers, climate research, and scientist education has produced significant advances in climate monitoring, understanding, and predictive capabilities. However, realization of socio-economic benefits from those investments remains incomplete, for many reasons. While climate researchers have collaborated with social scientists and decision makers to advance climate science applications, those collaborations have generally been limited to specific regions and sectors. However, experience within the NOAA-funded Climate Assessment for the Southwest (CLIMAS) has made clear that there are commonalities across sectors and stakeholders on which to base systemic advancement of climate information products and delivery. Systemic advancement requires accommodating the unique needs of decision makers, including the specific mix of multiple products required to support their decisions, the level of information certainty and forecast skill required for specific decisions, varying technical sophistication, and varying roles within decision making processes. Further, because decisions are made through the integration of knowledge and wisdom, with the latter more complex, diverse, and changeable than can be practically programmed in traditional computerized decision support tools, knowledge development is the most appropriate level for systemically providing improved climate products in support of the broadest range of decisions in an equitable manner.

Demonstration is provided of two Internet-based tools designed to enable systemic change in climate information delivery and decision support from a knowledge development paradigm. The first tool addresses cognitive barriers through tutorials, tools for exploring the time-evolution of forecasts and observations, user-customized assessments of forecast skill, and placing predictions in the context of historical and recent observations. The second tool addresses difficulties in simply accessing and managing the plethora of climate information from multiple sources, by providing user-managed project folders to store selected products for multiple applications and efficient access over repeated website visits, and dynamic PDF report generation that ensures inclusion of ancillary information while allowing customized interpretive comments (e.g., for delivery of information by intermediaries such as extension agents or state climatologists). The tools also provide ongoing feedback to operational agencies, science managers, and researchers about products preferred by different types of users and applications. However, highly interactive, user-customizable Web tools conflict with present federal policies and practices that prohibit user profiles, restrict use of industry-standard software, and require complex and time-consuming webpage approval, among others. As decision makers should adapt to changes in climate and information, federal agencies should adapt to changes in technology and user needs.

P-WE1.5

Barriers to Weather and Climate Forecast Use by Community Water System managers

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Weather and climate forecasts should have an important role in the management of water resources. Yet, most water resource managers make minimal use of these forecasts for managing risk and reducing the vulnerability of their systems to adverse weather and climate. In our research on relationships between producers and users of climate forecasts, we study the perceptions of Community Water System (CWS) managers in South Carolina and the Susquehanna River Basin of Pennsylvania to explore why they do or do not use weather and climate forecasts. We base our findings on the results of two mail surveys and three sets of follow-up interviews. The results reveal three barriers that prevent managers from incorporating weather and climate forecasts in their planning; each barrier has significant implications for communicating climate forecasts to resource managers and other stakeholders. First, the strongest barrier to forecast use is the managers' perceptions of risk. Those managers most likely to use weather and climate forecasts are those who have experienced weather and climate problems in the recent past; i.e., their heightened feelings of vulnerability are the result of negative experiences with weather or climate. The implication of this finding is that simply delivering weather and climate forecasts to potential users may not provide sufficient motivation for using the forecasts. Second, managers' concerns about weather and climate also vary with their physical context (water source, system size, and physical geography) and institutional context (the operational, financial, and regulatory setting). The implication of this finding is that assessments of vulnerability and information needs must consider the physical and institutional contexts of the resource systems and their managers. Third, if faced with weather- and climate-related problems, managers expect more difficulties with associated financial and regulatory issues than with their ability to procure water. Combined with the second barrier, the implication is that managers view weather and climate forecasts as more salient when put into the context of what they worry about—system operations and management needs. We conclude from this research that organizations providing information aimed at helping natural resource institutions manage the risks of weather and climate need to address the complexities of the organizational operations of those institutions. The most severe vulnerabilities of the institutions may not be to natural disasters or climate-induced resource scarcities, but to their inability to cope with natural disasters or resource scarcities simultaneously with other societal pressures and expectations.

P-WE1.6

Integrating Climate Information into Decision Making for Support of Water Management: A Protocol

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It was found that a major obstacle in using climate data products and predictions in water management decisions is how a product/prediction may be used in specific decisions. Although some applications are seemingly straightforward, such as using a prediction to decide if a future action is to take, correct and effective applications require much more than just taking the prediction and decide an action. Users often want to know an array of additional dimensions of a prediction before gaining confidence of how to use the prediction and if to use it in a decision, for example, if a prediction is valid for the area where a decision is to be made for, what is the probability for the prediction to be correct, if the prediction turns to be incorrect what loss it can bring to the users, and if the users may be able to absorb the loss and how they may make up for the loss. Besides these personal and financial concerns, community interest often also will affect decision makers in use of predictions, such as how a decision to use water at a decided amount may affect water availability to their neighbors (in drought situation, for example), and how his use may influence local water quality (e.g., in agricultural practice). In this intricacy of decision making, users need to know the scientific information as well as limitations in climate predictions and to have the skills to manage the uncertainty in the predictions while integrating them in specific decisions. Very few decision makers in water resources management and among agricultural producers (who use water in crop productions) have such knowledge and capacity, thus raising the needs for improving decision makers' knowledge and skills to effectively integrate climate predictions in decision-making.

In this report, we will introduce a web-based protocol designed using the learning tool of ThinkAboutIt. This protocol will show and train decision makers how various climate data products and predictions may be used in water management decisions. In this education and training tool, a decision maker after specifying a water use decision will be presented with a list of weather and climate data products and predictions. He can chose to either view a prediction or to ignore to use any of the information and make the decision. After making a decision and justifying it, he will be provided with a "coach." The coach will explain each among the list of weather and climate products and how it can be used for the decision.

After the coaching, the decision maker can revise his decision and justify it. A further iteration in this training is an "expert" in the protocol. The expert will provide additional perspectives of how and why certain products should be used in the decision and what consequences of a failed prediction might be mitigated to minimize losses. The decision maker is given another opportunity to revise his decision and give a justification. In this training process the user is shown the value and limitations of specific predictions and how they can be integrated with other factors in making specific decisions. Through such training and practice users will break the obstacle and gain both knowledge and confidence in using climate data products and predictions in water management decisions. Such gains will be measured from comparisons of the user revised decisions and justifications in the iterations of the training process.

Expansions of this protocol to other decisions can help achieve the goal of transitioning the climate research results and products to positive decision outcomes and benefits to the society.

P-WE1.7

Infrastructure to Document Local Hydroclimatic Vulnerabilities to Climate Variation and Change

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Climate change is a local problem. Anthropogenic climate change results from myriad human actions occurring in local places; people experience and respond to climate variations and change in specific localities. Data documenting local human causes and consequences of climate change is poor because of an inadequately developed scientific infrastructure. Consequently, the NSF/NOAA funded Human-Environment Regional Observatory (HERO) project is using three strategies to build prototype infrastructure for studying the long-term implications of climate variation and change at local scales. First, it is developing protocols for collecting, storing, reporting, sharing, and analyzing data. Second, it is building an intelligent networking environment for Web-based access, data management, and collaboration. Third, it is proving the HERO concept works by applying the protocols and intelligent networking environment to local climate change research problems at four human-environment regional observatories (HEROs) representing a diverse set of natural and human environments. The HEROs are located in the Arizona-Mexico border region, the High Plains of southwestern Kansas, the ridge and valley province of central Pennsylvania, and the restructuring manufacturing belt of central Massachusetts. To focus their proof-of-concept activities, the four HEROs are addressing the question, how does decision making affect the vulnerabilities of these places to hydroclimatic variation and change? Special attention is being given to three essential components of hydroclimatic vulnerability: exposure, sensitivity, and adaptive capacity. Long-term drought presents a major exposure threat at the two western sites, whereas floods and short-term droughts present a significant risk in Pennsylvania and Massachusetts. Water quality issues are a major sensitivity in the humid eastern sites, but water quantity (availability) is the primary concern at the semi-arid/arid western sites. Access to natural or financial resources tends to increase adaptive capacity across all sites. Protocols are being developed for quantitatively assessing exposures using standard statistical data and for qualitatively assessing sensitivities and adaptive capacities using community decision-maker interviews. Protocols are also being established to enable comparative analysis of research findings across the sites. In the end, the five-year HERO project is developing ways to gather and preserve precious scientific data, thus making it possible to answer critical questions about the complex local relationships among individuals, communities, and their climatic environments over time and space. It is demonstrating technological means to bring scientists and decision makers together to address fundamental issues linking nature and society.

P-WE1.8

Climate Information Needs for Decision Makers: Special Reference to Water

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In this presentation, we propose to discuss how decision-makers need to be informed about the impact of climatic change on water issues in Florida. As providers of information and decision-support, we will answer the following question: What information is needed by decision makers to make informed policy decisions? We will discuss the role of scientists in the dissemination of information to decision-makers. We believe that scientists need to generate and present information in a way that is easy to understand and can be translated into policy by decision makers. Our presentation will also highlight the relationship between water and other factors such as ecosystem and coastal changes. We are currently involved in compiling and evaluating information and methods available to address and support informed climate change decision-making processes and policies in Florida. We will present the efforts undertaken around the state in terms of information and methods being used to address the climate change issues. For example, is there a dialogue between scientists and decision- makers? Are they discussing the possible impact of climate change on water? Are decision-makers expressing to scientist their information needs to help them in policy development? What tools do decision-makers need to have at their disposal to properly deal with climate change issues and enact new laws related to water and its effects on the Florida ecosystems? At CES, we are in the process of assessing the decision-making needs in terms of management and planning capabilities of the state of Florida. CES is preparing a statewide conference to discuss the information available to and needed by decision-makers. The goal of this statewide forum is to identify current and future planning and decision-making needs based on climate change priority areas which might have an impact on water issues over the medium- and long-term. In our presentation, we will discuss the information available and needed for policy and decision-makers and how to introduce a new thought process to deal with the challenges of climate change in Florida. Our decision-support efforts are going to involve representatives from various local, state and government agencies, academic institutions and many other stakeholders (non-governmental organizations, business community, agriculture sector, etc.). This approach allows for the development of feedback and the definition of key issues in the decision-making process. Our forum will also play an important role in the assessment of the state of knowledge and the decision support resources available in Florida.

P-WE1.9

Adapting New York City's Water Supply and Wastewater Treatment Systems to Climate Change

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The New York City Department of Environmental Protection (NYCDEP), the agency responsible for managing New York City's water supply and wastewater treatment systems, created an agency-wide Climate Change Task Force in 2003. The mission of the Task Force is to ensure that NYCDEP's strategic and capital planning efficiently take into account the potential effects of climate change—sea level rise, higher temperature, increases in extreme events, and changing precipitation patterns—on NYC's water systems. In addition to its adaptation activities, the Task Force is developing a GHG management program, using GHG inventory software to support mitigation efforts.

The NYCDEP Task Force, in partnership with Columbia University's Center for Climate Systems Research (CCSR), is evaluating climate change forecasts, impacts, indicators, and adaptation and mitigation strategies to support agency decision making. A comprehensive framework for analyzing climate change has been created, including a 7-step Adaptation Assessment procedure. Potential climate change adaptations are divided into management, infrastructure, and policy categories, and are assessed by their relevance in terms of climate change time-frame (immediate, interim, and long-term), the capital cycle, and costs and other impacts. A wide range of potential adaptations has been examined, including integrated operations with other systems, storm surge barriers for wastewater treatment plants, and new design criteria for infrastructure that reflect non-stationary hydrologic processes. Climate change indicators have been identified to help guide the timing of adaptations.

Task Force activities also include the development of downscaled climate change scenarios, the coordination of scientific projects to yield maximum benefit from research and development, and internal and external outreach through climate change workshops. For the NYC region, downscaled climate change scenarios are being simulated using the MM5 regional climate model. Mechanisms for updating these scenarios over time are being developed, using evolving climate information on trends and extremes provided by university scientists. As an example of science coordination, Columbia University is coordinating a multi-institution project that integrates scenarios of climate change and sea level rise, hurricane and nor'easter storm-surge modeling and a digital elevation program to estimate flooding risks to coastal infrastructure. NYCDEP is also a member of the European Union CLIME project, helping to develop integrated regional climate and water quality models to study climate change issues in its watersheds. To support its ongoing programs, the Task Force meets monthly; it also engages NYCDEP personnel through climate change science and planning workshops.

P-WE1.10

The Water Cycle Solutions Network

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Earth is a unique, living planet due to its vigorous cycling, replenishing, transport, and transformation of water. Water is essential to life and is central to society's welfare, progress, and sustainable economic growth by serving as a resource for industry, agriculture, natural ecosystems, fisheries, aquaculture, hydroelectric power, recreation, and water supply. However, global water cycle variability which regulates flood, drought, and disease hazards is being continuously transformed by climate change, erosion, pollution, salinization, agriculture and civil engineering practices. Therefore, a national priority is to use our scientific knowledge to improve operational water cycle assessments, predictions & applications. NASA's unique vocation is to produce key scientific contributions using global observations from space and to exploit these contributions for improved Earth system monitoring and prediction. As such, NASA's Earth science programs have collected and archived substantial water cycle information archives and knowledge that must be integrated and reanalyzed to make decisive contributions toward solutions in all twelve national priority application areas. However, NASA alone cannot achieve the ultimate goal of improved operational environmental assessments, predictions and applications and therefore must establish collaborations with other research organizations, operational agencies, the scientific community and private industry.

Therefore, we are developing a Water Cycle Solutions Network (WCSN) that will establish pathways and partnerships between NASA's vast water cycle focus area research investments and various decision support needs. We are developing the WCSN by engaging relevant NASA water cycle resources and community-of-practice organizations to develop what we term an "actionable database" that can be used to communicate and connect NASA Water Cycle Research Results (NWCRRs) towards the improvement of water-related Decision Support Tools (DSTs). An actionable database includes enough circumstances or facts about its nodes that connections and pathways between these nodes are identifiable and motivated. We are initially focusing on identifying, collecting information about, and analyzing the two end points, these being the NWCRRs and water related DSTs. We will then develop strategies to connect these two end points via innovative communication strategies, improved user access to NASA resources, improved water cycle research community appreciation for DST requirements, improved policymaker, management and stakeholder knowledge of NASA research and application products, and identifying pathways for progress. Finally, we will develop relevant benchmarking and metrics, to understand the network's characteristics, and to optimize its performance. The resulting WCSN is designed to improve the collective ability of water cycle scientists, managers and stakeholders to routinely harness NWCRRs to address crosscutting water cycle assessment, prediction & management challenges.

P-WE1.11

Demonstrating Land Information System (LIS) Decision Support Solutions

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The focus of this crosscutting integrated systems solutions project is to develop, demonstrate, and enable the use of land surface research results to address multiple national application solutions. Knowledge of terrestrial water, energy, and carbon conditions are of critical importance to real-world applications such as agricultural production, water resource management, flood, weather and climate prediction, hazard mitigation and mobility assessment. A huge volume of land surface states and fluxes are being observed on the ground or from space, including surface temperatures, vegetation conditions, snow states, albedo, longwave and solar radiation, precipitation, surface moisture, freeze/thaw state, runoff, total water storage and elevation, among others. The need to interpret and transition these NASA land surface research results into decision support solutions has motivated the development of the Land Information System (LIS). LIS incorporates the following functionality to enable this transition: a high-resolution capable land data assimilation system, involving several independent community land surface models, land surface data assimilation technologies, and integrated database operations for observation and prediction data management; a web-based user interface that accesses data mining, numerical modeling, and visualization tools. LIS has been recognized by many partner agencies as a valuable tool for translating and interpreting NASA's vast Earth observation resources into information useful for decision support. Therefore, this work is being conducted in response to requests by these partner agencies to prototype LIS solutions, demonstrate them in the partner's operational environment, and characterize LIS performance. In addition, the data assimilation capability provided within LIS enables the optimization of NASA Earth science research results in partner DSTs using Observing System Simulation Experiments (OSSEs).

P-WE1.12

Drought Monitoring in Oklahoma: A Collaborative Endeavor

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Since the onset of an extended drought in 1995, the Oklahoma Climatological Survey (OCS) has been the key provider of precipitation-based drought assessments to state officials in Oklahoma. The decision-support system, designed collaboratively with officials at the Oklahoma Water Resources Board (OWRB), other state agencies, and U.S. Drought Monitor authors, uses real-time observations from the Oklahoma Mesonet to provide early detection of drought conditions.

Key features of the system include:

- Climate-division tables showing departures and comparisons to historical events;
- Statewide maps of rainfall patterns;
- Assessments for periods ranging from 30 days to 1 year;
- Links to other resources.

Information from the system is included in the Water Resources Bulletin, which is produced by the OWRB each month and distributed to top agency officials, legislative leaders, and Governor's staff to keep them informed on drought status by region in Oklahoma.

The drought decision-support system works so well because it was developed collaboratively between scientists and decision-makers. New products are added at the request of the decision-makers and prototypes are tested by these key user groups as new changes are implemented. OCS is working on expanding this system to a national basis, using daily information from the National Weather Service's Cooperative Observer Network.

P-WE1.13

Applying Planetary Water and Energy Cycle Science and Observations to Regional and Local Decision Making in the Water Sector

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This talk will review the recent and potential contributions of relevant elements of three global science and observation programs for management decisions related to the development and use of water resources. The three programs include the Global Energy and Water Cycle Experiment (GEWEX), the Integrated Global Water Cycle Observations (IGWCO) theme of the Integrated Global Observing Strategy Partnership (IGOS-P) and the water resources activities of the Global Earth Observation System of Systems (GEOSS).

GEWEX is a research program that has directed considerable effort towards the development of data bases at global and regional scales for use in the analysis of the climate system, in the development of prediction models in hydrology and meteorology and in the application of hydrometeorological sciences to water management. Currently, emphasis is being placed on the exploitation of these data bases, in combination with process understanding and modeling capabilities, to answer central questions regarding regional energy and water budgets and their response to seasonal variability. In addition, through its Water Resources Application Project and its Continental Scale Experiments, GEWEX is contributing to the local application of these global data sets in resolving water management issues. Contributions to this understanding are also coming through the Coordinated Enhanced Observing Period (CEOP) which is currently launching a watershed project.

The IGWCO was established by IGOS-P in 2003, to bring together international programs and national agencies to develop a framework for guiding decisions regarding priorities and strategies for the enhancement of water cycle observations in support of 1) monitoring climate variability and change, 2) effective macroscale water management and sustainable development of the world's water resources, 3) local societal applications for resource development and environmental management, 4) initialization of prediction models, and 5) priority water cycle science questions. IGWCO has been actively engaged in capacity building and linkages with the Global Water System Project (GWSP) and the Commission on Sustainable Development as part of its effort to achieve these goals. Plans are being developed strengthening water cycle observations and developing selected products that will be useful for water management. New approaches to water resources management are proposed through acceptance of the basic vision of IGWCO and the development of the requisite water cycle science, observational and modeling infrastructure.

The presentation will also describe the most recent plans for addressing the Water Resources Societal Benefit Area Targets in the GEOSS Ten-year Implementation Plan. It is expected that GEOSS will provide a mechanism to support upgrading national observational networks and data management so they will meet the information needs of decision makers in the water sector.

The talk will conclude with some discussion about ways in which these three international programs could more effectively support the decision support goals of the Climate Change Science Program.

P-WE1.14

Development and Presentation of Climate-Based Streamflow Forecast Tools for Water Resource Manages in the Puget Sound Region

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The Central Puget Sound's Water Supplier Forum (The Forum) is a collaborative group of Washington state municipal water suppliers, hydropower utilities, and city and county governmental agencies that was formed in July of 1998. This organization seeks to develop sustainable water resources management that is responsive to Endangered Species Act (ESA) and Growth Management Act (GMA) requirements of Washington State while recognizing tribal and stakeholder interests.

The Forum has contracted with the University of Washington to develop streamflow forecast tools for rivers in the Puget Sound area that provides water supplies to some 2 million people, serves as a critical habitat for several species of Pacific Salmon and provides hydropower production. One goal of this forecast system is to integrate traditional streamflows forecasts methods, such as Extended Streamflow Prediction or ESP, with recent advances in climate forecasting tools, to generate climate-based forecasts of stream flows and temperatures. A critical component of this research effort is the methods developed to convey climate and river forecast information to the interested parties in a manner that is both informative and timely for use in the ongoing decisional making process associated with system operation.

To this end a Web-accessible forecast system, updated on a monthly basis, was developed to present river forecasts at a variety of locations. Streamflow forecasts are presented both graphically and in a series of probability tables. Additionally, a narrative description and summary of the current climate and river forecasts has been developed for distribution to decisions makers via e-mail. Frequent information exchange, between the University researchers developing the climate based forecast tools, and the decision makers who might benefit from these tools, has informed and influenced the forecast presentation methods. This exchange has also yielded valuable insight into how the climate forecasts are used to refine and support fisheries resources as well as serving as a decision support tool for drought management.

P-WE1.15

Water Supply Forecasting for the Western U.S.

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Tom Pagano, USDA/NRCS

The effects of climate change and variability are having a direct and significant effect on Western water supplies. Recent extremes in precipitation and temperature have provided challenges to the accurate prediction of spring and summer snowmelt runoff. Up to 80% of the West's water supply is derived from snowmelt, which supports 25.5 million acres of irrigated croplands providing annual production values in excess of $51.1 billion. Water availability also plays a direct role in water rights decisions, power generation and sales, endangered species management and county level drought declarations. This presentation focuses on the science used by the Natural Resources Conservation Service to create the water supply-based resource products used by tens of thousands of Western water managers. The presentation will also focus on new and innovative methods to improve water supply forecasts accuracy, new visually relevant products for resource managers and the integration of climate indexes and forecasts with water supply forecasting procedures.

P-WE1.16

Hydroclimatic Reconstructions for Decision Support in the Colorado River Basin

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The recent drought and its associated impacts across much of the western USA created a window of opportunity for collaborations between scientists and water resource managers. Drought severity, particularly in 2002, was unprecedented in many gage records, leading to the question: Does the gage record contain an adequate frame of reference for drought planning? Consequently, we developed partnerships with water management agencies in the Colorado Front Range, producing tree-ring based streamflow reconstructions to examine water management assumptions about drought. The reconstructions are now being used in Colorado water resources planning and management. Collaborative investigations with Arizona's Salt River Project are also incorporating tree-ring insights in decision making.

In order to broaden the spatial scope and applications of paleoclimatic data in water resource management, we convened a workshop in May 2005 that brought together paleoclimatologists, hydrologists, climate scientists, and resource managers concerned with Colorado River Basin water supplies. We shared lessons learned through our partnerships and charted a course for future collaborations. Our water management partners made several presentations illustrating applications of paleoclimatic data to water resource planning. These provided a basis for discussions that addressed issues and needs related to the broader application of these data to water resources management. Workshop participants agreed on the value of tree-ring reconstructions for placing the instrumental record within a broader context of hydroclimatic variability and as decision-support resources for evaluating system reliability. Participants valued the two-way knowledge exchange between scientists and managers as a mechanism to improve scientists' understanding of decision-making concerns, as well as water managers' understanding of the science behind the data. For example, water resources managers routinely use probabilistic information, but need more transparent characterization of the uncertainties in the reconstructions. The workshop demonstrated that mutual understanding can reduce barriers to paleodata use in decision making.

Needs identified by water resource managers have provided guidance for future activities and collaborations. Managers recommended additional workshops to provide (1) technical training for operational use of paleodata, (2) general information workshops for higher-level water resources decision-makers and their publics, and (3) online guidance documents and resources to make paleodata accessible for water resources applications. We plan to follow up on these recommendations in coordination with an advisory board of water management personnel. This presentation summarizes the workshop outcomes and ongoing activities, and examines the effectiveness of scientist-stakeholder workshops as a means to convey paleoclimatic information, foster collaboration, and enhance CCSP implementation.

P-WE1.17

California's Coupled Water and Energy Response to Climate Change

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During normal to wet years, up to 80% of California's fresh water is from Sierra Nevada snowmelt runoff, and during prolonged drought periods this resource is from groundwater storage. Historically, California's economy has relied heavily on groundwater recharge as a form of drought insurance. Groundwater recharge, which is sensitive to climate change, climate variability, and climatic extremes, is controlled by feedbacks between the atmosphere, land surface, and groundwater, and is impacted by conjunctive use and related electrical demands. Our research group at Berkeley Lab, in collaboration with the California Department of Water Resources (CDWR), is investigating physical and economic sensitivities of California's water system and related energy resources as a function of reservoir storage, groundwater recharge, and climate change and variability. The outcome of our findings is part of the CDWR's State Water Plan, a decision policy statement for future water planning. This work couples the physical system to economic pricing of electrical energy needed for groundwater water pumping and conveyance.

We have designed a sensitivity experiment based on a series of drought scenarios ranging in duration from 5 to 30 years, with net precipitation decreases ranging from 5 to 75%. Understanding this range of drought scenarios within California's surface and groundwater system gives new insight to climate change impacts on California's economy. By developing 30 year drought scenarios with a range of precipitation reductions, we will have a representative climatology as an analogue to the projected 25 to 75% reduction in Sierra Nevada snowpack due to increasing near-surface air temperature.

An outcome of this study is to provide the State with an analysis of simulations of the water storage-energy system with reduced uncertainties, with criteria for increased resilience and efficiency. In this presentation we provide details of our (1) analysis of the related changes in precipitation and temperature to changes in surface flows into reservoirs and groundwater flows into aquifers; (2) analysis of how changes in surface and subsurface storage management impact water supply to downstream agricultural and urban users and (3) analysis of how changes in surface storage practices impact hydropower generation and how changes in subsurface storage practices impact pumping electricity/energy demands.

P-WE1.18

The Role of Climate Change in Thermoelectric Cooling Water Systems

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Climate change is expected to alter the meteorological, hydrological, and ecological regimes on which the performance of thermoelectric cooling water systems depends. It will affect the capacity of cooling towers, constructed ponds, and natural water bodies to transfer waste heat from steam condensers to the atmospheric boundary layer, and the cascading effects of climate change on aquatic ecosystems (for example, reduction in fish habitat attributable to increased water temperature and decreased dissolved oxygen) may prompt new regulatory criteria for cooling water systems. We consider how utilities make strategic decisions about cooling water systems amidst climate change, evolving regulatory criteria, and evolving water management policies.

We review studies of strategic decisions for cooling water systems based on operations simulations with historical hydrometeorological time series data. Climate change will add to the uncertainty of such analyses, and we discuss the magnitude of that uncertainty relative to other sources of uncertainty in cooling water simulations. Uncertainty of future greenhouse gas emissions from anthropogenic sources begets uncertainty in global climate model predictions, which are downscaled with regional climate models to yield prognostic localized hydrometeorological time series. Modeling compromises and assumptions in future climate predictions and downscaling methods introduce additional uncertainty into the process.

We examine the value utilities place on climate change information for use in cooling water simulations with to study alternatives for adapting to changing environments. Utilities will adapt to climate change and other impetuses with the aim of maximizing cooling water system performance and, ultimately, dependable capacity, efficiency, and energy production of fossil and nuclear generating units.

P-WE1.19

Climate-Driven Increases in Extreme Heat and Energy Demand in California

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Summer temperatures in California under scenarios of future climate change are projected to increase considerably, accompanied by longer, more frequent, and more severe extreme heat conditions. These projections have important implications for energy demand in California, a region where suppliers are already challenged by growing population and increasing summer demand. Here, we analyze the potential impacts of rising temperature on California heat and energy demand based on projections from three atmosphere-ocean general circulation models (AOGCMs) – HadCM3, GFDL, and PCM – forced with the IPCC SRES with higher (A1fi), mid-high (A2), and lower (B1) emission scenarios.

By 2100, state-wide summer temperature increases range from 2-5ºC under the lower B1 scenario up to 4-8ºC under the higher A1fi scenario, with shifts towards more frequent extreme heat conditions occurring through changes in both the mean and variance of summer temperatures. Through statistical downscaling of daily temperatures, we generated Cooling Degree Day (CDD) projections that reflect a base human comfort level related to air conditioning for eight California cities, ranging from El Centro in the southeast to Crescent City in the northwest. CDD values increase by 20 to 200% under B1 and 25-700% under A1fi by mid-century, with even larger increases ranging from 24 to 600% (B1) and 60 to 3000% (A1fi) by end-of-century. CDD projections show the largest increases for coastal areas, and increase northward from Los Angeles to San Francisco to Crescent City.

Using observed correlations between energy demand and temperature, we then estimate the additional energy supply that would be required to meet CDD demands based on a sliding scale from 65ºF (the current-day definition) up to 75ºF (which simulates the potential role of adaptation). Without taking into account the competing effects of population increases, technological advances, or adaptation strategies, we estimate that by 2100 California could require more than 10,000 MW of additional power during peak summer days for residential cooling purposes alone, an amount that exceeds current-day California energy capacity by 17%.

Based on these projections, future brownouts and blackouts may be more frequent, unless active prevention measures are taken and decision-makers today are informed of possible future change in order to implement mitigation and adaptation strategies. Such strategies could include anything from building more capacity (and its consequent feedbacks on the global climate system) to active prevention measures such as increased energy efficiency practices, conservation, and reliance on alternative energy sources.

P-WE1.20

Climate Change Impacts on California's Energy Security Planning

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Los Alamos National has traditionally supplied decision support tools and analyses to federal decision makers on problems of national security. The effect of climate variability and change on the security of the nation's energy supply is no exception to this long tradition. This presentation describes the combination of critical infrastructure models with climate change data as a novel example of this decision support.

Many climate models have predicted temperature increases on a global scale due to the impact of increasing atmospheric concentrations of greenhouse gases. Questions remain as to the manifestation of climate impacts at regional scales where policy decisions can be most effectively implemented. A recent study by Hayhoe et al. have used downscaling techniques from global climate models to predict regional climate changes across California over the course of this century. The present study uses this downscaled temperature data to predict the increase in electrical demand and infrastructure bottlenecks that will develop in California over the 2005 to 2035 time frame due to predicted temperature increases of 1 to 2 deg. C. The results show that in the absence of climate change, population growth and economic expansion in California will require 57,000 Megawatts of new generation capacity and new construction must begin in 2022. A modest predicted increase in temperature of 1-2 degrees Celsius due to climate change, however, would increase the new capacity requirements to 68,000 Megawatts—costing an additional $64 billion per year (including fuel) and pushing up the construction start date to 2015. In addition, electricity price increases of 12% in real terms ($123 per megawatt-hour in 2035 in constant 2000 dollars) will occur. Federal and state government will require new regulatory and pricing policies to cope with these price increases.

This example highlights the need by decision makers in the energy regulatory sector for accurate regional scale predictions over the time scale required for planning and siting new energy generation facilities, especially in our most stressed electrical markets.

P-WE1.21

Using Climate Models Output in Adapting to Climate Change

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Among the most important reasons that managers of natural resources have found it difficult to incorporate the potential effects of climate change into long-term resource planning are the uncertainties about regional climate change and the long time horizon over which climate change will unfold.

Many climate change impact studies have relied on a limited number of scenarios examining impacts as far ahead as a century from the present. For example, they might have one scenario with wetter conditions and another scenario with drier conditions far in the future. Natural resource managers have tended to find such information too uncertain and remote from the present to be useful for decision making.

One way to help overcome these obstacles to incorporating climate change into natural resource management is to survey regional output from a large number of climate models. Such information can give a better indication about the range of possible changes in regional climate. Output from 17 models in the CMIP data base (Covey et al., 2003) were normalized so regional model outputs can be compared based on relative regional changes in precipitation and temperature. These models are compared on 5 x 5º grids in SCENGEN in order to assess the degree of agreement or disagreement across models regarding the sign and magnitude of changes in temperature and precipitation. The climate model MAGICC (which is used in IPCC assessments) is used to estimate changes in global-mean temperature using different greenhouse gas emissions scenarios, different climate model parameters (such as the climate sensitivity), and time (Wigley, 2004). Regional results from the climate models in CMIP are scaled by projected increases in global-mean temperature. MAGICC/SCENGEN can be used to estimate the probability of an increase in temperature or in precipitation at a regional scale.

Results are applied to decision making in three cases: flood control planning in La Ceiba, Honduras; water resource planning in Limpopo Province, South Africa; and assessment of the possible impacts of climate change on skiing in Aspen, Colorado. In each case, we are working with decision makers to apply and interpret the outputs from MAGICC/SCENGEN to aid in planning for development of infrastructure, evaluation of adaptation strategies, and long-term resource use and management. MAGICC/SCENGEN is run within planning horizons for projects and resource management. It can provide information on the extent to which climate models agree or disagree about changes in temperature and precipitation. While such results should be used with caution, because model agreement could be fortuitous, nevertheless, this unique and comprehensive information can be useful in informing long-term natural resource management decisions.

Covey, C., AchutaRao, K.M., Cubasch, U., Jones, P.D., Lambert, S.J., Mann. M.E., Phillips, T.J. and Taylor, K.E., 2003. “An overview of results from the Coupled Model Intercomparison Project (CMIP).” *Global and Planetary Change*. 37: 103–133.

Wigley, T. M. L. 2004. “MAGICC/SCENGEN.” Boulder, Colorado: National Center for Atmospheric Research. http://www.cgd.ucar.edu/cas/wigley/magicc/

P-WE2.1

Giovanni – A Vital Tool Enabling Rapid and Accurate Climate Data Analysis for Evaluation, Assessment, and Research

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The Goddard Earth Sciences Data and Information Services Center (GES DISC) has created the GES DISC Interactive Online Visualization and ANalysis Infrastructure, “Giovanni,” to enable Web-based analysis of several NASA remote-sensing climate data sets. Giovanni was conceived as a research tool to increase the “usability” of climate data sets, but it can also be used to evaluate climate data for purposes of overview and site assessment, trend detection, anomaly detection, and identification of significant events and potential hazards. The simplicity of Giovanni allows users unfamiliar with the scientific and technical details of Earth remote sensing to utilize climate data for the purposes of short-term and long-term decision making, and the determination of future research needs.

Giovanni features a simple user interface allowing rapid access to data, establishment of spatial and temporal criteria, and a variety of output options. The data analysis engine provides rapid statistical analyses and generation of area average plots, time plots, Hovmoller latitude vs. time and longitude vs. time plots, vertical profiles, data set intercomparisons, and anomaly analysis. Giovanni has been applied to several different climate data sets, including precipitation, atmospheric chemistry, ocean color, and sea surface temperature.

P-WE2.2

Global Land Data Assimilation System (GLDAS) Products Available to Support Hydroclimatology and Decision Making

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The Global Land Data Assimilation System (GLDAS) ingests satellite- and ground-based observational data products, using advanced land surface modeling and data assimilation techniques, in order to generate optimal fields of hydrological land surface states (e.g., soil moisture and snow) and fluxes (e.g., evaporation). GLDAS drives multiple, offline (not coupled to the atmosphere) numerical models of land surface processes. Through these it integrates a huge quantity of observation based data. It is able to run globally at high resolutions (2.5° to 1 km) and can produce results in near-real time. Observation-based precipitation and downward radiation products, as well as output fields from the best available global coupled atmospheric data assimilation systems, are employed to force the models. The high-quality, global land surface fields provided by GLDAS support several current and proposed investigations of weather, climate, and water resources predictability. GLDAS has been selected as a primary integration tool for scientific products resulting from NASA's Energy- and Water-Cycle Sponsored Research (NEWS) initiative. Twenty-five year simulations with three sophisticated land surface models, parameterized and forced by the best available data, have recently been completed. Preliminary analyses indicate that the resulting fields may be valuable for identifying trends and teleconnections in the global water cycle.

P-WE2.3

Drought Monitoring and Applications of NASA's Hydrosphere States Mission

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NASA's Hydrosphere States Mission, to be launched in 2010, will provide the first global view of the Earth's changing soil moisture and surface freeze/thaw conditions, enabling new scientific studies of global change and atmospheric predictability, and making new hydrologic applications possible, including drought monitoring. Hydros will make unprecedented measurements of Earth's changing soil moisture and the freeze/thaw status of land surface that, together, define the state of Earth's hydrosphere. This state links the water, energy and carbon cycles over land. Hydros measurements will open new frontiers in our understanding of how these global cycles work together in the Earth system. Numerical models used for day-to-day weather prediction need soil moisture estimates as initial conditions for forecasts. Incorporating real observations into these models will significantly improve forecast accuracy. Soil moisture is among the top terrestrial environment measurement requirements of the Departments of Defense and Transportation because of the impact on land navigation and aviation weather. Contributing partners for the Hydros mission, in addition to NASA, include the Canadian Space Agency and the Department of Defense. The Hydros science team draws from several universities, NASA centers, research and operational branches of federal agencies. The principal investigator is Dr. Dara Entekhabi of the Massachusetts Institute of Technology, Cambridge, Mass.

P-WE2.4

The Hydrologic Ensemble Prediction Experiment (HEPEX) Project

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The goal of the HEPEX project is to bring the international hydrological and meteorological communities together to demonstrate how to produce reliable hydrological ensemble forecasts that can be used to make decisions that have important consequences for the economy, public health and safety and the environment. The project is overseen by an international User's Forum Council composed of representatives of organizations with a strong interest in using or applying HEPEX results, as well as a Science Steering Group. Nine international test-bed projects are being developed, including projects in Brazil, Canada, Europe and Bangladesh as well as the United States. This presentation will review users' expectations, science issues, project objectives, the status of the test-bed projects and possible relationships between HEPEX and the CCSP.

P-WE2.5

Climate Services for Water Resources Decision Support: An Overview of the State of the Practice and Some Implications Associated with Global Warming

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Climate-related decision support for water resources planning and management involves the production of a number of different kinds of hydrologic forecasting products and related services tailored to the specific needs of the water resources planning and management communities. At shorter time scales (e.g. lead times of a few weeks to 12 months) ensemble streamflow forecasts in specific river basins are useful products for water management. Climate forecasts (e.g. numerical forecasts of ENSO, PDO, PNA indices) can be used directly in hydrologic forecasting systems to create conditional probability distributions of future streamflows as a function of climate forecast information. These kinds of approaches are now fairly well-developed in the academic community, and we discuss the UW West-Wide forecasting system as a case study. Forecasting systems in the operational forecasting community are, in general, less well developed in terms of incorporating climate information and there is an ongoing need to transfer academically developed procedures and tools to the operational communities that directly serve many public sector water managers. Climatic change, although frequently viewed as a separate problem, actually plays a potentially important role in these kinds of forecasts, particularly in temperature sensitive river basins, because the probability distributions of streamflow may systematically change over time. Detrended temperature records for ESP forecasts, or temperature forecasts produced by climate models are two approaches that show some promise in dealing with these issues. Statistically-based streamflow forecasting methods that are trained on a long period of record (the norm in most operational forecasting systems) may contain systematic biases because of regional warming trends. Physically-based hydrologic simulation tools (e.g. the VIC and DHSVM hydrologic models used in the UW experimental forecasting systems) can directly relate altered temperature regimes to changes in snowpack and streamflow timing (or other effects) and may therefore perform more robustly in a rapidly evolving climate system than statistical approaches.

For water planning purposes at longer time scales (i.e. 10-100 years), long range projections of streamflow variability are needed to evaluate alternative water management plans. Using physically-based hydrologic simulation tools, the incorporation of systematic warming simulated by global climate models (GCMs) is relatively straight-forward using scenario based approaches. A number of effective downscaling approaches are available for temperature ranging from simple sensitivity experiments using "delta method" approaches to more sophisticated statistical and dynamical downscaling techniques. The same downscaling approaches have frequently been applied to the task of evaluating potential changes in precipitation, however because of greater underlying uncertainties in GCM precipitation simulations, quantifying precipitation uncertainties remains a significant challenge. The nature of these uncertainties, combined with relatively small GCM sample sizes, suggests that multi-model "super ensemble" or Monte Carlo approaches may be more effective for estimating precipitation uncertainties. Forecasts of energy (supply and demand), water demand, and water quality (particularly temperature) also play an important role in water resources management and planning. Climate is a key variable in such predictions, and as for streamflow, operational forecasts at both short and long time scales using physically-based tools are needed.

P-WE2.6

Assessing the Implications of Climate Variability and Change for Western Water Resources

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The hydrology and water resources, and hence the economy, of the western U.S. is highly sensitive to climate. Over the last 10 years, we have developed an approach that couples macroscale hydrology models to represent the large river basins of the west to climate models for purposes both of forecasting streamflow at seasonal lead times, and for assessing the impacts of climate change at century time scales. In both cases, a key step is removal of bias in climate model predictions using a probability mapping procedure, and downscaling from the spatial scale of GCMs to the hydrology model scale. This step is facilitated by knowledge of the climatology (probability distribution) of the hydrology model forcings from both the climate model and observations. We illustrate applications of this general approach both to the seasonal prediction, and climate assessment problems.

Since 2003, we used have used a variation of the above approach to produce real-time ensemble hydrologic predictions using our Variable Infiltration Capacity (VIC) macroscale hydrology model at lead times of six months to a year. Climate forecast ensembles are downscaled from climate models and the CPC official seasonal outlooks. As a benchmark, we also produce forecasts using the well-known Extended Streamflow Prediction (ESP) method, and the ESP forecasts are further composited to provide ENSO and PDO-conditioned ensembles.

The Accelerated Climate Prediction Initiative assessment of hydrologic and water resources consequences of climate change over the western U.S. used a variation of the same probability mapping method. Multiple ensembles from the NCAR/DOE Parallel Climate Model (PCM) were downscaled and bias adjusted to produce hydrology model forcings for three major western U.S. river basins—the Columbia, the Sacramento-San Joaquin, and the Colorado. The Columbia and Sacramento-San Joaquin basin results are strongly sensitive to the seasonal shifts in streamflow associated with climate change. These hydrologic shifts are reflected in reductions of "firm" hydropower production, and/or reduction in the system's ability to meet minimum spring and summer streamflow targets for fisheries protection and enhancement in the case of the Columbia. For the Sacramento-San Joaquin, the fraction of the time that the system would be in "critically dry" status more than doubles by mid-century. In contrast, the Colorado River reservoir system is almost completely insensitive to seasonal runoff shifts, but is highly sensitive to the approximately 10 percent reduction in annual runoff predicted by mid-century under the PCM scenarios. This change would reduce the system's ability to meet water supply delivery targets, and to meet U.S.-Mexico treaty obligations.

P-WE2.7

Impacts of a Warming Climate on Water Availability in Snow-Dominated Regions

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Predictions of future climate conditions in a greenhouse world are sometimes ignored because they are "uncertain." One common trait of all greenhouse predictions to date (warming of the near surface air temperature) has a profound negative impact on regional hydrology, particularly in snowmelt dominated environments: warmer air temperatures cause reductions in maximum snow accumulations, earlier melt, and hence earlier spring runoff. These impacts occur almost independently of changes in future precipitation. (These same simple physics will apply, at least in part, to the world's mountain glaciers and may partially explain why they are in retreat over most of the globe.) The model-predicted changes are already seen in the observed data. If maintained at current levels, these changes will lead to a serious reduction in dry season water availability in many regions of the Earth within the next few decades. The fact that all models predict a warming, and that warming is being observed now, suggests that mitigation strategies can be undertaken now with high confidence.

We present new results from a global land surface hydrology model that identifies the regions of the globe where snowmelt dominates the seasonal patterns of streamflow. In general, we find that snowmelt dominates those parts of the globe that are at latitudes greater than ~45° (North and South), with some exceptions for mountainous regions, regions that are warmed by oceans, and cold dry regions that experience little wintertime precipitation. The disappearance of the glaciers and snow pack reduction affect over one-sixth of the world's population. We also utilized a global data set of major reservoirs to identify regions where reservoir storage is large enough that timing shifts associated with earlier snowmelt are likely to be mitigated by reservoir storage. This is the case, for instance, in the U.S. Colorado River basin, but globally, only a relatively small part of the area identified as being hydrologically dominated by snowmelt would have global warming effects substantially mitigated by reservoirs. In total, we estimate that one-quarter of the global GDP is in areas that are susceptible to change in seasonal patterns of snowmelt.

P-WE2.8

Effects of Water Resources: Monitoring Snowmelt Runoff and Sea Level for Climate Change

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Substantial changes in mountain snowmelt water supply and sea level are projected to occur as a result of global warming. Water resources managers already collect extensive data to use in forecasting and in operations of water projects. If interested in climate change, they should look carefully at their long-term records of operating projects to see if signs of change are apparent and what the rates of change are. Hydrologic records are inherently highly variable and long stable records and reconstructed natural stream flows are needed to assess systematic changes over time.

The author will present a couple of samples from northern California of the time history of the long term fraction of mountain water year runoff occurring during the April through July period of snowmelt runoff. A second chart will show sea level rise on the California coast. Both parameters show a decrease in the rate of change in the last 15 years. Reconstruction of natural flows will be briefly discussed as well as why change in runoff patterns and in sea level are so important to the large water projects in California.

P-WE2.9

Regional Impacts of Climate Change, Land Use Change, and Human Population Dynamics on Water Availability and Demand across the Southeastern U.S.

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Projected changes in population, landuse, landcover, and climate could negatively impact the regional water resources in the southeastern U.S. The objective of this study is to develop a method to fully budget annual water availability for water supply [Precipitation - Evapotranspiration (ET) + Groundwater supply + Return Flow] and water use from thermoelectric, irrigation, domestic, industry, livestock, mining, and commercial sectors. We used a generalized annual ET model that estimates water loss as a function of potential ET, annual precipitation, landcover type, and topography. Both the groundwater supply and return flow rates were derived from USGS historical databases. Water use for the domestic, irrigation, and thermoelectric sectors for the future were projected using empirical models derived from historical USGS databases. They were mainly affected by population, irrigation land area, population, and water use efficiency of power generation, respectively. The Water Supply Stress Index (WSSI) as the ratio of water demand and supply was developed to evaluate water stress conditions. The Water Supply Stress Index Ratio (WSSIR) was developed to quantify the average or annual water stress impacts from future changes in climate, landuse, and population individually or in combination. Modeling results from two Global Circulation Models (GCMs) (UK Hadley2CMSul and Canadian CGC1), one landuse change model, and one population change model were integrated to project future water supply and use over the next 50 years. All model runs were performed at the 8-digit USGS Hydrologic Unit Code (HUC) level across 13 southern states. We found that population increase will greatly increase water use in metropolitan areas, but overall its impact on total water use may not be as large as surmised. Predicted future landuse changes (i.e., urbanization) will have little positive effect on water supply-water use relations. In contrast to population and landuse change, climate change and groundwater supply may have serious consequences on regional water supply and demand. In summary, we developed a framework and integrated modeling tool for water resource managers and policy makers to address climate change impact and associated global change issues at the regional to continental scales.

P-WE2.10

Decision Support System (DSS) for the Effects of Climate Change on Water Supply in San Juan River Basin

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We have developed a DSS to analyze and present water supply information at various river segments of the arid San Juan River Basin under various scenarios of climate change and drought. The DSS contains a watershed model (WARMF), which uses the topographic data (DEM) of the river basin (42,000 km^2) and is driven by meteorological data (46 stations). A batch scenario tool was developed to construct climate scenarios based on historic data from 1985 to 2004, which contained 4 wet, 4 dry, and 11 normal years. The climate change scenarios assumed temperature increases of 0, 1, and 2°C. Drought sequences of 3 and 5 years were hypothesized by using the batch scenario tool to randomly select meteorological records from the pools of wet, dry and normal year. Fifty selections were made for simulations to provide adequate characterization of uncertainty. The results showed that climate change produced more impact on the hydrology of watersheds at higher elevation. The hydrographs of USGS gauging stations, that receive runoff from high mountain areas, had earlier rises and lower peaks during the snowmelt period. Annual runoff was reduced 8 to 10% by 1 degree warmer temperature. Without climate change, three years' drought dropped the elevation of Navajo Reservoir briefly to 1,822 meters above mean sea level, 3 meters below the minimum required for the siphon pump to divert water to the Navajo Indian Irrigation Project. With one degree warming, the pool elevation was substantially lower for a longer duration. Reservoir releases had to be reduced to maintain the minimum pool elevation. A 35% (8% due to drought and 27% due to warming) reduction of drought year release for two years was required, if it was initiated early in anticipation of the prolong drought. The adjustment increased to 65% for one year, if the action was delayed. The DSS predicted a ripple effect of reduced reservoir releases on downstream water supply. The DSS will be used by stakeholders (local, state, federal governmental agencies, industry, Native American Tribes, and irrigation districts) to understand the scientific facts about the hydrologic system and to evaluate suitable water shortage sharing schemes, that may include using gray water to reduce the diversion for power plant cooling, changing riparian vegetations to reduce evapotranspiration, changing crops to alter the seasonal irrigation demands, reducing diversions equally and/or trading diversions among stakeholders.

The paper is a contribution from the ZeroNet Water-Energy Initiative of Sandia National Laboratory, Los Alamos National Laboratory, Electric Power Research Institute, and Public Service Company of New Mexico.

P-WE2.11

An Assessment of the Effectiveness of Riparian Buffers for Reducing Sediment Loading to Streams Under Alternative Climate Change Scenarios

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Sediment loading to streams in agricultural watersheds is a major cause of stream impairment. Factors affecting sediment loading include watershed physiographic characteristics, cropping practices, and climate. During the last century, much of the U.S. has experienced warming temperatures and increased rainfall. Projections of future climate change suggest these trends are likely to continue. Areas experiencing increases in rainfall are thus vulnerable to increases in sediment related stream impairment. An improved ability of decision makers to predict and respond to these changes is desired.

Riparian buffers are an effective and widely applied management practice for reducing sediment loading from agricultural fields. Buffer effectiveness is strongly influenced by hydrologic processes, however, and could vary in response to changes in precipitation. Buffer width and vegetation type also influence the effectiveness of buffers in retaining sediments.

In this study we assess the influence of changes in precipitation on soil erosion and sediment loading to streams from a 160-meter hillslope consisting of a corn field and riparian buffer. Climate scenarios were generated using the CLIGEN weather generator by modifying historical precipitation probability (i.e. describes the number of events that occur) and event intensity (i.e. describes the intensity of events) parameters by -10, 10, 20, and 30% at two locations, Athens, Georgia, and Salinas, California. Soil erosion from the corn field was simulated using the WEPP model. Sediment was then routed through the REMM model to simulate transport through a riparian buffer and into the stream. Sediment retention by forested and grass buffers ranging in width from 0 to 50 meters were assessed. This approach provides illustrative examples of the nature and magnitude of watershed response to potential changes in precipitation, and is not based on specific climate projections.

Results show that soil erosion is sensitive to changes in precipitation probability and intensity, but is more sensitive to changes in intensity. Increases of 10% in precipitation probability and intensity resulted in increases in erosion of 20 and 35%, respectively. Buffer trapping efficiency (percent of input that is retained) is altered relatively little, but large increases in sediment loading still occur. For example, with a 30-meter buffer, increases of approximately 100% occurred with a 30% increase in precipitation probability or intensity. Decision support tools based on this modeling approach could be used to help watershed managers achieve sediment management goals over a range of time scales.

P-WE2.12

Assessing the Impact of Climate Change on the Hydrology and Water Quality of the Upper Mississippi River

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Recent observations and modeling suggests acceleration of the hydrological cycle at high latitudes in the Northern Hemisphere and that extreme intense precipitation events were more frequent over the last 30 years of the twentieth century. Assessments of local and regional impacts of changes in the hydrological cycle in future climates call for improved capabilities for modeling the hydrological cycle and its individual components at the subwatershed level. We have evaluated the impact of climate change on stream flow in the Upper Mississippi River Basin by use of a regional climate model (RCM) coupled with a hydrologic model - Soil and Water Assessment Tool (SWAT) - and by use of an ensemble of GCMs producing output for the IPCC 4th Assessment Report coupled to SWAT. Both the RCM and the GCM ensemble reproduce quite well the annual flow and interannual variability of observed streamflow of the UMRB for the 20th Century. Individual low-resolution GCMs give poor simulation of annual streamflow, but the one high-resolution GCM tested gave good results.

The RCM driven by a single GCM (HadCM2) results for the decade of the 2040s gave a 21% increase in future precipitation, which resulted in a 51% increase in surface runoff, 43% increase in groundwater recharge, and 50% net increase in total water yield in the UMRB on an annual basis.

Although there is inconsistency among GCMs, the ensemble-mean precipitation increased of 6% due to climate change. ET calculations give positive changes for all models, likely due to warm-season temperature increases. Substantial decreases in snowfall suggest that warming is strong in winter. Runoff decreases substantially for most models, possibly due to enhanced drying of soils between rains. Total water yield varied widely among models, with the ensemble mean showing almost no change from the contemporary climate.

Fugitive nitrates and sediment are carried by overland flow related to runoff. However, the dominant pathway for nitrate loss is through leaching to groundwater and then via baseflow or tile drains. Results show a substantial decrease in runoff in the future climate but increase in baseflow, although with less agreement among models. From this we speculate that both sediment and nitrate loading of streams would decrease due to decreased runoff but that nitrate leaching might increase. Therefore, although water quality might improve due to reduced sediment, the loading due to nitrates is less clear but might increase.

P-AQ1.1

Integrating Climate Modeling and Remote Sensing Data to Improve Public Health Decision Support Tools: Model Results – Part II

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The December 15 and 16, 2003 dust storm described in a previous talk spread across New Mexico, west Texas, and northern Mexico. The Dust Regional Atmospheric Model (DREAM) model we used to simulate this storm is nested within the NWS/NCEP/Eta operational forecast system of the National Weather Service. Our aim is to produce an operational dust forecast and early warning system for health and air quality public services.

In this paper, DREAM model results of four climate scenarios as reflected in land cover will be presented. The four scenarios represent climate circa 1980; current climate; and two hypothetical future climates of drier and wetter conditions in the southwest. The results show that NASA earth science observations yield up-to-date land cover and, therefore, improve model results which are fed into public health decision support tools. The decadal changes of land cover due to climate variation and other reasons, such as agricultural activities, have great impact on the modeled air-borne dust concentrations. Model results of the two hypothetical climate scenarios demonstrate the potential of the prospective dust

P-AQ1.2

Possibilities and Challenges in Using Satellite Data for PM2.5 Forecasts

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Satellite remote sensing has brought our observation of the Earth's atmosphere into a new era, and remote sensing capability could lead to a quantum leap in our ability of air quality monitoring and prediction. In terms of aerosols, the most common quantity from satellite retrieval is the atmospheric column aerosol optical thickness (AOT), and the most common quantity indicating air quality at the surface is the concentration of PM2.5. We present here the relationship between the column AOT and the surface PM2.5 from a global aerosol model GOCART and from satellite instruments MODIS and MISR and surface measurements from EPA and IMPROVE networks. We will discuss the possibilities and challenges in using satellite data for PM2.5 forecasts, and if model-satellite assimilation can improve the forecast quality. We will focus on the following questions:

- Can satellite observations of AOT be quantitatively used for surface PM2.5 monitoring and forecasting?
- Can model assimilation of satellite AOT data improve the quality of PM2.5 forecasting?

P-AQ1.3

Satellite-Derived High Resolution Land Use/Land Cover Data to Improve Urban Air Quality Model Forecasts and Decision Making

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Under the Clean Air Act (CAA), local and state agencies are responsible for developing State Implementation Plans (SIPs) aimed at attaining and maintaining the National Ambient Air Quality Standards (NAAQS). Typically, the Decision Support Systems (DSSs) used for this purpose utilize numerical models to simulate the physical and chemical processes that govern the transport and transformation of criteria pollutants and their precursors within the region of interest. Within these models, the specification of land use plays an important role in controlling land surface energy and water fluxes, which in turn affect the near-surface meteorology and emissions. Accurate land use characterization has the potential to improve the accuracy of the modeling results and would thus be of great value to federal and state agencies. Researchers from the NASA Marshall Space Flight Center have worked with the Georgia Environmental Protection Division (GEPD) to incorporate an improved high-resolution land use characterization data set (LandPro99 merged with National Land Cover Data, NLCD) within the modeling system. The dataset provides a more accurate representation of the current land use. It also allows a more robust assessment of future land use changes in the region through the use of the Spatial Growth Model (SGM). Meteorological and air quality forecasts made using the high-resolution land use data for two summertime high ozone episodes in 1999 and 2000 were compared against the lower-resolution traditional land use data previously used in the AQMDSS. It was found that use of the high-resolution data improved performance of the meteorological model substantially, with the overall daytime cold bias reduced by over 30%. The air quality model performance for ozone did not show an improvement. Increased boundary layer mixing simulated using the high-resolution land use data negates the effects of warmer near-surface air temperatures, with the net effect on ozone being near zero. In additional, land use changes in the Atlanta area due to urbanization were predicted through 2030 using the Spatial Growth Model (SGM). Modeling simulations with the projected land use predicted higher urban air temperatures. The incorporation of urban heat island mitigation strategies (i.e., highly reflective roofing and increased tree canopy) partially offset this warming trend. Recommendations and lessons learned from this research are being incorporated by the GEPD to improve their air quality modeling DSS for the Atlanta metropolitan area.

P-AQ1.4

Global Atmospheric Pollution Studies Using Space-Based Observations Alongside Global Modeling and Data Assimilation Tools Developed in NASA's Global Modeling and Assimilation Office

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The paper addresses our ability to use available and planned observations to understand the distributions of atmospheric pollutants and their interactions with global climate and air quality. It is most relevant to the "Air Quality" theme of the workshop. The work strongly addresses the second topic of interest, "Evaluation of the current state of observations, modeling, or other research and its appropriateness for use in decision making at different scales," in that it directly addresses characteristics and quality of space-based data and aspects of transport in present-day models.

The foci of discussion will be ozone and carbon monoxide, which have different characteristics, making them sensitive to diverse aspects of model uncertainty and subject to different types of observations. For ozone, discussion will address the value and limitations of assimilating space-based observations for enhancing our understanding of radiative forcing of climate, long-range transport, and air quality. Existing space-based ozone data give information on total and partial atmospheric column burdens (from the TOMS, SBUV, and OMI instruments), stratospheric profiles (from limb-emission measurements, such as the EOS-MLS instrument), or partial columns in the upper troposphere (from the AIRS and TES instruments). Future (active) sensors may be developed to detect near-surface ozone concentrations. Carbon monoxide can be deduced from infrared emission measurements, which give information about deep layers in the middle and upper troposphere (the MOPITT and AIRS instruments). Results will discuss:

- Estimates and error bars on ozone radiative forcing of climate, including sensitivity to the inhomogeneous ozone data record and the evolving network of meteorological observations.
- Confidence in the vertical profiles of ozone and carbon monoxide determined by data assimilation of space-based data, and the consequent value of these products to our understanding of long-range (inter- and cross-continental) transport of pollution and on air quality. Impacts of limitations in both the observations and the model processes will be evaluated.
- The likely role of future (active) measurements in addressing weaknesses of the present network, and the potential for observation system simulation experiments (OSSEs) to aid in the design of new space-based measurements.

P-AQ1.5

Effects of Urbanization on Meteorology, Biogenic Emissions, and Air Quality in the Houston-Galveston Area (HGA) in Texas, USA

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Changes in the land use (LU) and land cover (LC) not only affect physical characteristics involved in surface flux and radiative energy exchanges, but also influence the amount of biogenic emissions produced by the vegetation. Both the meteorological and emissions input data are important in determining the air quality in a region. Urbanization effects of the Houston-Galveston area (HGA), Texas, USA, on the meteorology, biogenic emissions, and air quality, are studied with a satellite derived high resolution LU/LC data. The siting of coastal cities makes them particularly vulnerable to climate change. We have developed the idea by exploring how shifts in land use and land cover affected local heat islands, land-sea breezes, and air temperatures. In the case of Houston, extensive and ongoing deforestation was leading to significant rises in ozone concentration with potential knock-on effects for public health. Meanwhile, any improvements in car emissions was more than off-set by growth in traffic and further changes in land cover thanks to the construction of extra road surfaces. Only very reluctantly was a comprehensive assessment of land use and land cover being factored into policy making. Further we suggest far more work needed to be done in assessing the health effects of regional climate change and air quality. Using combined field plot information, satellite estimates of tree cover (stratified by the land use type specified in the new dataset), and detailed leaf mass density (LMD) data for HGA developed by the US Forest Service, we estimated changes in the biogenic emissions. The new biogenic emissions showed significant differences over the areas with large changes in the vegetation cover. Finally, we simulated air quality model with the new meteorological and emissions inputs to study the overall impacts of using the updated LU/LC dataset in the photochemical modeling of high ozone events in the Houston-Galveston nonattainment area. Comparative modeling simulations were performed with the 1990, 2000, and projected 2010 LU/LC datasets. This study demonstrated reduction of urban heat island effects by selectively planting more tree species that produce less isoprene emissions and increasing other vegetation area in the HGA has beneficial effects on improving ozone problems.

P-AQ1.6

Accounting for Uncertainty in Future Climate Change and Evaluating Its Effects on Regional Air Quality

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Precise forecast of future climatic conditions has typically been difficult due partly to the presence of large uncertainty in estimating various factors that can affect climate, e.g. emissions released into atmosphere from natural sources and human activities. This leads to an unclear level of uncertainty in evaluating future regional air quality which is dependent on both meteorology and emissions in the future. In this modeling study, a paradigm of regional air quality modeling over the continental US has been set up using the PSU/NCAR MM5 model and the US EPA CMAQ model for control year 2001 and future year 2050. A scenario of projected future anthropogenic emissions is assumed and a nominal (or base) scenario of future meteorology adopted for use is based on the downscaled results from the NASA GISS global climate model. Uncertainty in climate change is incorporated into the modeling through 1) numerically coupling perturbation values suggested by the results from the MIT Integrated Global System Model (IGSM) to a nominal future meteorological field of interest (here, temperature field) and then 2) performing meteorological downscaling to the regional scale. This poster is to present the overview of how uncertainty in climate change is quantified and the preliminary results of its effects on regional ozone and fine particulate matter levels.

P-AQ1.7

Examining the Impact of Climate Change and Variability on Regional Air Quality over the United States

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The United States has established a series of standards for criteria and other air pollutants to safeguard air quality to protect human health and the environment. The Climate Impact on Regional Air Quality (CIRAQ) project, a collaborative research effort involving multiple Federal Agencies and academic institutions, examines global climate change scenarios as they might affect regional and urban tropospheric air quality in North America for ozone and fine particles. Global climate simulations have been derived from the NASA Goddard Institute for Space Studies (GISS) version II'(two prime) model assuming the IPCC Special Report on Emission Scenarios (SRES) A1B "business as usual" emission scenario. Scientists with the Department of Energy (DOE) Pacific Northwest National Laboratory have used these scenarios to provide boundary and initial conditions to a regional climate model (RCM) based on the Fifth Generation Pennsylvania State/National Center for Atmospheric Research (NCAR) Mesoscale Model (MM5). Finally, the RCM was used to generate10 years of present (~2000) and future (~2050) hourly climate scenarios for the continental U.S. over a grid of 36km by 36km cells. Results for analyses of RCM surface temperature, surface wind, precipitation and steering level transport patterns on various time scales (e.g., seasonal, annual, inter-annual) have been compared to historical point and gridded reanalysis datasets as well as to the future RCM scenario decade. These comparisons are used to identify some key model biases and uncertainties on temporal and spatial scales relevant to regional and national air quality assessment. In the next year, RCM simulations will be used as meteorological drivers in the development of 5-year time series of present and future climate-driven emissions and air quality scenarios generated through the Community Multiscale Air Quality (CMAQ) modeling system. Results of the CIRAQ project contribute to the U.S. Climate Change Science Program assessments addressing the effects of global change on human health and welfare and human systems.

The research reported here was performed under the Memorandum of Understanding between the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Commerce's National Oceanic an Atmospheric Administration (NOAA) and under agreement number DW13921548 and contributes to NOAA's Air Quality and Climate Programs. Although it has been reviewed by EPA and NOAA and approved for publication, it does not necessarily reflect their policies and views.

P-AQ1.8

Assessing Potential Health Impacts of Ozone and PM2.5 Under a Changing Climate

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Whereas potential impacts of climate change on heat-related illnesses have received considerable attention, less is known about climate-related changes in air quality and corresponding health effects. To address this need, the New York Climate & Health Project (NYCHP) developed and applied a modeling framework designed to generate downscaled estimates of ozone and PM2.5 air quality under alternative scenarios of global climate change, and to relate these changes to potential human health impacts. The modeling framework linked the global Goddard Institute for Space Studies (GISS) general circulation model (GCM) with regional climate (MM5) and air quality (Community Multiscale Air Quality - CMAQ) models to estimate hourly surface ozone and PM2.5 concentrations over the eastern U.S. on a 36 km grid for the summer seasons (June–August) for five consecutive mid-decadal years (e.g., 1993-1997) in the 1990s and 2050s. The outputs from the air quality simulations were used to evaluate the modeling system against observed ozone and PM2.5 data, to project future concentrations throughout the 36 km eastern U.S. modeling domain, and for assessing potential public health impacts within the study area. For assessing health impacts, mortality risks were estimated using exposure-response relationships derived from the literature. Results showed that both ozone and PM2.5 were sensitive to climate change, and that public health impacts could increase over time in the absence of mitigation and/or adaptation efforts. This modeling strategy could be applied in other metropolitan areas, for other climate change scenarios, and for other health outcomes to assess potential health impacts of air pollution under a changing climate.

P-AQ1.9

Criteria for Evaluation of Heat Event Early Warning Systems

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Introduction

Heat events are associated with marked short-term increases in mortality, particularly in mid-latitude countries. In regions where extreme hot weather is infrequent, major heat events are associated with excess mortality, such as in the midwestern U.S. and Europe. Studies quantifying the impacts of heat events in developed countries consistently find that the elderly are most at risk, although physiological studies suggest that cardiovascular fitness may be more important than age for individual thermoregulation. Early warning systems are being designed to alert the population and relevant authorities in advance about developing adverse meteorological conditions, then to implement effective measures to reduce adverse health outcomes. Although these systems are considered to be effective, there is very little published information on formal (quantitative or qualitative) assessments of the effectiveness of systems as a whole or of individual intervention measures.

Methods

We evaluated literature on heat event responses in Europe and the United States and interviewed stakeholders in Europe regarding response plans to formulate criteria for evaluation of such systems.

Results

Heat event early warning systems are difficult to evaluate, partly because heat events are rare events, with varying characteristics between events, and because high temperatures have different impacts in different populations. Most systems have not been operational for extended periods. The number of deaths avoided per heat event day is typically low and therefore it is difficult to quantitatively evaluate heat event warnings. The system components should be evaluated to ensure that the process of issuing a warning is effective. Criteria were developed for planning, implementing, and on-going evaluation of the system, including: describe the components and operation of the system; describe the resources used to operate the system; and evaluate the system for simplicity, acceptability, sensitivity, timeliness, and effectiveness of individual response measures.

Discussion

Heat events are a public health problem that have, until recently, received insufficient attention from both meteorological and public health agencies. Clear performance standards and regular performance evaluations can build public awareness and confidence in these systems, thus increasing their usefulness.

P-AQ1.10

Integration of NASA Data into ArboNET/Plague Surveillance System

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A basic understanding of a region's landscape ecology is useful for predicting the future course of plague outbreaks and identifying areas of high risk for humans. In the case of plague prevention and response efforts, the Center for Disease Control and Prevention (CDC) has partnered with NASA to explore the use of remote sensing products into the CDC's ArboNET plague surveillance system (PSS). The incorporation of Earth science data into the ArboNET/PSS was designed to employ different remote sensing models and techniques that will ultimately allow CDC to deploy these new capabilities operationally in support of their plague science and management decision making. The use of remote sensing for epidemiological studies is not new. The temporal and spatial distribution of most infectious and vector-borne diseases are affected by a combination of environmental factors such as vegetation, temperature, landscape structure, and rainfall. This paper summarizes the relationships between climate variables as provided by MODIS, AVHRR, LandSAT, TRMM, and SRTM sensors and the frequency of human plague cases (1981-2002). Results show that temporal variations in plague risk can be estimated by monitoring these key climatic variables and allow a better characterization of the spatial and temporal dimensions of plague vector habitats.

P-GC1.1

Warming of the World Ocean, 1955-2003

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Analysis of historical oceanographic temperature data documents that the world ocean has warmed since 1955. The magnitude of this warming is consistent with the amount of warming expected due to the observed increase of greenhouse gases in Earth's atmosphere since the Industrial Revolution began. Several atmosphere-ocean general circulation models exhibit a similar ocean warming in their model ocean, only if the atmospheric components of the models are forced by the observed increases of greenhouse gases. Ocean warming is a critical indicator of the state of Earth's climate system. Only the world ocean can store the additional heat expected to accrue in Earth's climate system as a result of increasing greenhouse gases. Thus the observed ocean warming provides Decision Makers tasked to deal with changes in Earth's climate system additional critical evidence that global; warming is occurring.

P-GC1.2

Assessing the Risk of a Collapse of the Atlantic Thermohaline Circulation

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In this paper we summarize work performed by the Climate Research Group within the Department of Atmospheric Sciences at the University of Illinois at Urbana-Champaign (UIUC) and colleagues on simulating and understanding the Atlantic thermohaline circulation (ATHC). We have used our uncoupled ocean general circulation model (OGCM) and our coupled atmosphere-ocean general circulation model (AOGCM) to simulate the present-day ATHC and how it would behave in response to the addition of freshwater to the North Atlantic Ocean. We have found that the ATHC shuts down "irreversibly" in the uncoupled OGCM but 'reversibly' in the coupled AOGCM. This different behavior of the ATHC results from different feedback processes operating in the uncoupled OGCM and AOGCM. We have represented this wide range of behaviour of the ATHC with an extended, but somewhat simplified, version of the original model that gave rise to the concern about the ATHC shutdown. We have used this simple model of the ATHC together with the DICE-99 integrated assessment model to estimate the likelihood of an ATHC shutdown between now and 2205, both without and with the policy intervention of a carbon tax on fossil fuels. For specific subjective distributions of three critical variables in the simple model, we find that there is a greater than 50% likelihood of an ATHC collapse, absent any climate policy. This likelihood can be reduced by the policy intervention, but it still exceeds 25% even with maximal policy intervention. It would therefore seem that the risk of an ATHC collapse is unacceptably large and that measures over and above the policy intervention of a carbon tax should be given serious consideration.

P-GC1.3

Estimating the Probability of Future Climate Shifts

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Recent research has pointed to the existence of natural, generation-scale (15-40 year) climate phases, or regimes, related to the influence of the Atlantic and Pacific Oceans. These decadal-to-multidecadal (D2M) swings in ocean temperatures have had significant impacts on air temperature, rainfall and severe storms in North America, Europe and Africa. Most importantly, D2M climate regimes have impacted the frequency of extreme events, such as droughts, floods, hurricanes and environmentally linked health problems. The natural D2M climate regimes have alternately camouflaged and exaggerated the effects of anthropogenic climate change, and are being studied, among other things, in order to reduce the uncertainty in regard to the magnitude of the anthropogenic influence. Modern computer models used for D2M studies—unlike those used for the more short-lived El Niño—are not yet capable of predicting future shifts in the D2M climate regimes. However, thanks to recent tree-ring reconstructions of past D2M regime shifts over a half-millennium or more, we now have the ability to project the probability of future regime shifts with useful accuracy. With further collaboration between climate scientists and risk managers, such as water management engineers, it is hoped that this new area of study will lead to the development of an increasingly useful suite of decision support tools for water, health, agriculture and disaster mitigation.

P-GC1.4

More on Hockey Sticks: The Case of Jones *et al.* [1998]

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Multiproxy studies purporting to show 20th century uniqueness have been applied by policymakers, but they have received remarkably little independent critical analysis. Jones *et al*. [1998] is a prominent multi-proxy study used by IPCC [2001] and others to affirm the hockey stick shaped temperature reconstruction of Mann *et al*. [1998]. However, the reconstruction of Jones *et al*. [1998] is based on only 3-4 proxies in the controversial Medieval Warm Period, including non-arms-length studies by Briffa *et al*. [1992] and Briffa *et al* [1995]. We show that the Polar Urals data set in Briffa *et al* [1992] fails to meet a variety of quality control standards, both in replication and crossdating. The conclusion of Briffa *et al*. [1995] that 1032 was the "coldest year" of

the millennium proves to be based on inadequate replication of only 3 tree ring cores, of which at least 2 are almost certainly incorrectly crossdated. We show that an ad hoc adjustment to the Tornetrask data set in Briffa et al [1992] cannot be justified. The individual and combined impact of defects in the Polar Urals data set and Tornetrask adjustments on the reconstruction of Jones et al [1998] is substantial and can be seen to have the effect of modifying what would otherwise indicate a pronounced Medieval Warm Period in the proxy reconstruction. Inhomogeneity problems in the Polar Urals and Tornetrask data sets, pertaining to altitude, minimum girth bias and pith centering bias will also be discussed.

P-GC1.5

Assessment of U.S. Climate Variations Using the U.S. Climate Extremes Index and the U.S. Greenhouse Climate Response Index

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Karl *et al*. (1996) developed two indices to quantify observed changes in climate within the contiguous United States, a US Climate Extremes Index (CEI) and a US Greenhouse Climate Response Index (GCRI). The CEI is based on a combination of climate extreme indicators, while the GCRI is a combination of indicators based on projected changes due to greenhouse climate change. These indices integrate changes in climate over several different temperature and precipitation measures and are likely to provide early detection of important changes in climate in the United States. The CEI and the GCRI should be useful for decision making because they provide concise summaries of changes in temperature and precipitation extremes over the US, relevant to many climate impact areas including energy and water use. The CEI is updated annually and used for operational climate monitoring at NCDC (available at http://www.ncdc.noaa.gov/oa/climate/research/cei/cei.html). Karl *et al*. (1996) noted an increasing trend in the CEI in recent decades and a significant positive trend in the GCRI during the 20th century. However, attribution of these observed changes to specific causes was not possible, as they were not directly compared with climate model simulations.

An assessment of variations of the CEI over the twentieth century has been undertaken, including comparison of the observed indices with those calculated from global climate model simulations. Some issues with the interpretation of variations in the CEI have been identified. A new version of the GCRI has been developed. Significant increasing trends have been found in the components of the new GCRI associated with extreme maximum and minimum temperatures, due to fewer cold extremes and more hot extremes across the continental US. These variations are outside the range of internal climate variations simulated by climate models and are consistent with the models' responses to increasing greenhouses gases and sulfate aerosols. Hence, it is likely that anthropogenic climate forcing is contributing to changes in temperature extremes in the United States. There have also been recent changes in the components of the new GCRI associated with precipitation extremes, with more rain days and more intense rainfall, but it is harder to separate any anthropogenic influence from internal climate variations.

Karl, T.R., R.W. Knight, D.R. Easterling, and R.G. Quayle, 1996: Indices of climate change for the United States. *Bull. Am. Meteor. Soc.*, **77**, 279-292.

P-GC1.6

Relative Sea Level Trends from Tide Stations: How Are They Determined and What Do They Tell Us?

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The NOAA National Ocean Service operates a National Water Level Observation Network to serve a variety of NOAA missions, including marine transportation, weather and water, habitat restoration, and climate. Many of the stations have been operating continuously for over 50 years and are accumulating time series from which accurate relative sea level trends can be determined. This is accomplished only through proper operation and maintenance of the tide gauges, maintenance and routine leveling of the local tidal bench mark networks for monitoring vertical stability, and quality control of the data and output products at various time steps. Sea level trends and variations determined from tide stations provide information relative to the land and contain vertical movement due to local and regional land movement as well as components due to long-term global sea level rise. Researchers have made estimates of global sea level rise from selected global tide stations by correcting them with large scale tectonic models, and tide stations are being used to calibrate and evaluate global sea level trend estimates from satellite altimeter missions. Recent research includes integration of relative sea level trends with long-term continuous GPS measurements. Estimates of sea level trends from tide stations are also a key component of trying to understand the current mass balance of the oceans and how the mass balance may be changing due to thermal expansion and freshwater input from melting glaciers and Antarctic and Greenland icepacks. In a practical sense, sea level trends derived from tide stations are used for a variety of decision-making and assessment applications, including surveying and mapping, coastal engineering, habitat restoration, and coastal management. NOAA produces an online product that gives the latest information on relative sea level trends at coastal and ocean island stations (http:/tidesandcurrents.noaa.gov/sltrends/sltrends.shtml).

P-GC1.7

A Maturity Model for Satellite-Derived Climate Data Records

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There is considerable confusion in both the scientific community and the general public about how to define a climate data record (CDR) produced from satellite remote sensing data. This confusion appears in the diversity of vocabularies, experiences, and backgrounds used to describe the suitability of data for climate-related work. In this paper, we describe a set of metrics that provides an objective framework for evaluating the suitability of describing a data collection as a CDR. This framework should reduce the community confusion, improve the reliability of conclusions drawn from CDR data, and assist in strategic management of these data by identifying areas needing improvement.

We define the model in terms of three dimensions of maturity:

1) Scientific Maturity, particularly the quantification of measurement uncertainty,
2) Preservation Maturity, particularly the documentation of data collection, production, and provenance,
3) Societal Impact of the data.

Within each of these dimensions, we identify key attributes of maturity and then rank the maturity of a data collection for each attribute on a scale of 0 to 5. This approach avoids dependence on just one or two metric values and provides a balanced view of the different areas of maturity.

For scientific maturity, we heavily weight the ability of a CDR to reliably extract a meaningful measure of decadal or longer trends in a field of interest. We discuss a simple model of the measurement process that clearly identifies a trend and compares a simulated measurement of the trend with its true value. By running an ensemble of cases that cover the statistics of the measurements and their errors, we can quantify how far the true trend might lie from a measured value – a quantification we call the "fidelity interval" of the measured trend. The statistical approach we suggest is extensible to a variety of measurement approaches and is sufficiently realistic to allow us to incorporate a variety of calibration and validation activities. In addition, by quantifying the resource requirements and schedule for these activities, we can provide an initial estimate of the cost/benefit value of the proposed schedule in terms of reduced uncertainty.

For preservation maturity, we start with two fundamental principles: that long-term usability of data requires minimizing the probability of loss (whether through physical damage or through loss of ability to find relevant information) and minimization of the cost of archival operations. By extending these principles in practice, we are able to quantify maturity in terms of a modest number of attributes that can be ranked on a scale similar to the one we suggest for assessing scientific maturity.

For societal impact (or benefit), we are particularly concerned with assessing the change in social and economic terms of reducing the uncertainty of climate trends. This is, of course, a difficult task that again requires a probabilistic statement of maturity. As with several other approaches to climate change assessment, the maturity model needs to help decision and policy makers by providing realistic assessments of the probability of a wide range of impacts.

To increase the strategic management capability of the maturity model, we observe that each of the three axes can be associated with costs or benefits. Scientific maturity and preservation maturity both require expenditures, and may therefore be associated with "debit accounts" for a particular CDR. The benefit of making the measurement and using the data is associated with a "credit account." Thus, our maturity model provides both a an objective approach to assessing the suitability of calling a measurement set a Climate Data Record and provides a start at assessing the return on investment that is available by maturing the measurement and preservation processes.

P-GC1.8

The Contribution of Earth Science Remote Sensing Data to Natural Resources Policymaking

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This paper traces the evolution of space-derived remote sensing data and data products from their initial dissemination to their eventual impact on the nature and outcome of public policy addressing climate change issues. We focus on the example of renewable energy. Our approach is different from previous studies that have characterized the value of data in terms of the fundamental scientific phenomena they describe. Our research seeks to assist in answering the question posed by Congress, the Office of Management and Budget, managers at the National Aeronautics and Space Administration, and other decision makers about what, if any, have been other contributions of space-derived earth science.

P-GC1.9

Accessing NOAA Daily Temperature and Precipitation Extremes Based on Combined/Threaded Station Records

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Daily records of both temperature and precipitation are of great interest to the public and many data users. However, numerous station relocations over the years have resulted in inconsistent approaches to combining multi-location data sets, resulting in disparate reporting of record and extreme values at many prominent large metropolitan observing sites.

In the interest of ensuring consistent reporting of climatological data, NOAA's National Climatic Data Center (NCDC), in partnership with the Northeast Regional Climate Center (NRCC), NOAA's National Weather Service/Climate Services Division, and numerous data users, has established a data set of combined (or threaded) period of record daily temperature and precipitation values at approximately 300 NOAA published Local Climatological Data locations. This new data set provides a consistent basis for the reporting of daily, monthly, and annual extremes for the longest period of time meaningful. The development of this data set is especially timely given the increasing availability of historic daily values in digital form for the first half of the 20th Century (and earlier in some cases).

This presentation provides a discussion on the methodology for establishing multi-location combined (or threaded) station data sets, preliminary applications of the data, and schedules for its public release.

P-GC1.10

NOAA Climate Prediction Center Products for Decision Making

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NOAA's Climate Prediction Center (CPC) continues developing a wide range of climate products for decision makers and applications. Information on climate variability, real-time climate "nowcasts," and climate outlooks from "Week-2" through seasonal to interannual time scales are important to decision makers in energy, agriculture, public safety and other sectors of the economy. In response to user needs, NOAA expects to continue developing scientific resources for decision making, and refined products and product presentations to enhance their utility for applications. Producers and consumers of climate information have developed adaptive management and planning capabilities. Improvements are being developed for communicating scientific information, including incorporation of information about levels of confidence and uncertainty in decision-making.

The CPC produces educational materials to help users better understand the role of the climate system in our lives, as well as the limitations and usefulness of climate forecasts. The partnerships that have developed through the production and use of climate variability products provides a nucleus and resource for understanding the process by which climate change products may be developed, improved, and applied for maximum utility.

The CPC is responsible for operational delivery of monthly and seasonal climate outlooks, extended range outlooks for Week-2 (6-10 and 8-14 days out), advisories and outlooks, for El Niño, La Niña, the Atlantic hurricane season, degree days, drought, and an ultraviolet (UV) radiation index. The CPC's outlooks and forecast products complement the short range weather forecasts issued by other components of the National Weather Service (e.g. local Weather Forecast Offices, and National Centers for Environmental Prediction). These weather and climate products contribute to NOAA's Seamless Suite of Forecast Products.

CPC's role as a "producer" in the above activities, with its partners inside and outside NOAA, results in a unique opportunity to assist the community of decision makers in understanding and applying the integration of weather, climate, and impacts across all time scales.

P-GC1.11

Aerosol Direct Radiative Effects Over the Northwest Atlantic, Northwest Pacific, and North Indian Oceans: Estimates Based on In-Situ Chemical and Optical Measurements and Chemical Transport Modeling and Their Relation to Decision-Support Information

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Aerosols influence the climate system via scattering and absorption of solar radiation, changing cloud properties and altering precipitation. The largest uncertainty in the radiative forcing of climate change over the industrial era is that due to aerosols (IPCC-2001). This uncertainty arises in part due to the uncertainty in scattering and absorption of shortwave (solar) radiation by aerosols of anthropogenic origin in cloud-free conditions. Aerosols are short-lived and, hence, highly variable on local and regional scales. The forcing by aerosols varies on regional scales and depending on absorption differs can be higher at the surface than at the top of the atmosphere. Aerosols also influence local surface temperature and moisture. Therefore, aerosols impact all five major themes of this workshop: water, ecosystems, coastal issues, energy and air quality.

Reduction in the uncertainty in aerosol's influence on climate and building a better predictive capability are major goals of the CCSP activities. Quantitatively, evaluating the current capability is a distinct milestone in this endeavor. To this end, the measured aerosol properties over three regions of the globe downwind of major urban/population centers were used to calculate the aerosol forcing due to light scattering and absorption. Directly measured aerosol burdens (mass), aerosol extinction optical depth, and aerosol properties were used to calculate the climate forcing via scattering and absorption (change in radiative flux due to total aerosols) and compared against models. In-situ and remotely sensed aerosol properties for each region were used as input parameters to radiative transfer models to constrain the models. The "a priori" and "constrained" model results were then compared. The uncertainties in each step were determined and propagated through the analysis. The results demonstrate that when the radiative transfer models were constrained by observational inputs they have a lower uncertainty than the models with "a priori" parameterizations (e.g., IPCC- 2001), and thus help reduce uncertainty in the estimation of the impact of aerosols on climate.

The results from this study will (i) assist the IPCC (2007) assessment and will (ii) form input into future CCSP activities that will include evaluations of the radiative forcing by aerosols into specific 2007 decision-support information products. The use of observational constraints helps base choices on real world, observationally-vetted, decision tools that are expected to be more quantitative; they also help improve model development for future predictions.

P-GC1.12

Response of a Coupled Chemistry-Climate Model to Changes in Aerosol Emissions

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In this study, we analyze the response of the coupled chemistry-climate (the NCAR Community Atmosphere Model, CAM3) system to changes in aerosol emissions in fully coupled atmospheric chemistry-climate-slab ocean model simulations. Using this model we have performed a set of simulations that highlights the role of aerosols over a wide range of emission scenarios. Under these conditions, we focus on the two most basic ways aerosols can impact a coupled chemistry-climate model: direct radiative forcing and chemical uptake. In particular, we have chosen to simulate the state of the atmosphere when many of the aerosol (or their precursors) emissions are explicitly set to 0. While this is an unrealistic scenario (all aerosol emissions have some natural component to them), it provides an interesting upper limit scenario to the results of a possible decrease in aerosol emissions from their present-day estimates. We show that, at the global scale, a decrease in emissions of the considered aerosols (or their precursors) produces a warmer and moister climate. Without aerosols, the globally-averaged surface temperature is approximately 0.5 °C warmer. In addition, the tropospheric burdens of OH and ozone significantly increase when aerosol emissions are decreased. These chemical responses are shown to be a combination of the impact of reduced heterogeneous uptake and impact (such as increased ozone loss) of a moister atmosphere.

P-GC1.13

Aviation and the Global Atmosphere: The State of the Science and Future Research Needs

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Greenhouse gas emissions from aviation have grown and should continue to increase commensurately with increasing aviation activity. However, the direct impact of aviation on climate via the emission of green house gases is small relative to other anthropogenic sources. Nevertheless, the potential impact of aviation on climate is unique and important because aviation associated sources occur at significant altitude where other anthropogenic sources are absent. Also, aviation's relative contribution to greenhouse gas inventories will likely grow against a background of other industries being able to switch to alternative forms of energy and significantly reduce greenhouse gas emissions.

In 1999, a major publication was written by authors from the broad community of aviation and atmospheric science under the auspices of the Intergovernmental Panel on Climate Change, *Aviation and the Global Atmosphere* [IPCC, 1999]. The report included a thorough documentation of the state of understanding of how emissions at cruise altitudes affect the atmosphere. The estimated impacts due to various emissions and the degree of confidence in the estimates of their impacts were presented and have been since been quoted often.

The authors of the IPCC *Aviation and the Global Atmosphere* report recognized that there were significant scientific uncertainties surrounding aviation's impact on the atmosphere. These include the influence of contrails and particles on cirrus clouds, the role of NO_X in changing ozone and methane concentrations, and the atmospheric processing of water near the tropopause. Furthermore, investigators have since noted that assessment of the relative impact of various emissions did not take into account the varying lifetimes of various emissions, an omission which could have significant impact and potentially lead to flawed policy decisions and mitigation options.

This presentation will review the present state of knowledge of aviation's impact on the global atmosphere, including uncertainties. It will highlight areas of needed research to reduce these uncertainties to levels that enable appropriate action. It will highlight potential options for mitigating aviation's greenhouse emissions. And ultimately, it will seek to catalyze debate and action on tackling these issues.

P-GC2.1

Simulations of Committed Climate Change and Sea-Level Rise through 2400 AD

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The effects of sea-level rise in the next few centuries are of particular concern for coastal regions and many island nations. This talk summarizes simulations of the minimum, or committed, sea-level rise for the 21st through 23rd centuries based upon models analyzed for the IPCC AR4. The committed sea-level rise is the increase in sea-surface level associated with the historical changes in greenhouse gases to date and the associated trends in ocean temperature and ocean volume. The results, at least for the 21st century, are unaffected by future scenarios of emissions and emission controls. Both simple and complex models of the ocean atmosphere system suggest that global-average sea level will increase by approximately 10 cm over the next century. These results represent the minimum increase in sea level, since most of the complex models neglect the effects of melting continental ice sheets, including those of Greenland and the Antarctic ice sheets.

P-GC2.2

Model Evaluation and Projections of Climate for the Middle and Upper Atlantic Region of the United States

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The Consortium for Atlantic Regional Assessment (CARA) aims to provide information to stakeholders through an interactive web site in order to help them make decisions that may be affected by climate change and land use in the Mid- and Upper-Atlantic Region of the United States. Model evaluations and projections are an essential component of the climate assessment process. In that spirit, we have analyzed the regional output of seven global climate models forced by two greenhouse gas emissions scenarios from 1900 to 2100. We evaluated the models in terms of their long-term means and variability (seasonal, interannual and decadal) using the temperature and precipitation observations at U.S. Historical Climate Network (HCN) stations. Because model and observed topographies differ substantially (due to the coarse resolution of the models), an altitude correction is made to the temperature output of the models, which reduces simulation errors by 20%, on average. When averaged over the models, the simulated mean temperature at the HCN stations for the current climate (1971-2000) is 0.12ºC higher than observed, with typical (i.e., RMS) errors of 1.4ºC. The mean precipitation at the HCN stations for the current climate has a model mean of 3.0 mm per day, which is equal to the observed, and typical errors are about 15%. Model seasonality in temperature was evaluated using the difference between the summer (June-August) and the winter (December-February). The model-mean seasonal difference is 14% larger than observed. Observed precipitation in the region is highest in summer and lower in winter. The model-mean summer-winter difference in precipitation is about 10% greater than the observed, but the phasing of precipitation is generally ahead of the observations, with four of the models putting highest precipitation in spring and five putting lowest precipitation in fall. Analysis of simulated interannual variability, decadal variability and future projections, which were not completed at the writing of this abstract, will also be presented.

P-GC2.3

Development of Regional Probabilities of Climatic Change for Decision Making

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It is known that in some resource sectors, such as water resources, probabilistic information about future climate, can be useful for decision making by e.g., water managers. Several techniques have now been developed to provide, specifically, regional probabilities of climate change. We will present an assessment of these methods, including those of Tebaldi et al. (2004, 2005), Greene et al. (2005), and Raisenen (2005). These three methods make use of the newest simulations of climate change by AOGCMs produced for the IPPC AR4. In this regard, the methods are all based on multi-model ensembles (multiple AOGCMs running the same climate experiments), and two of them take a Bayesian approach. The three methods produce different results for large regions, particularly in the width of the distributions. Even though these methods should be viewed primarily in the research mode, we present some examples of how such probability distributions could be used in a decision making context. Use of these research results by stake holders (e.g., water managers) can be useful for pedagogical purposes, and such iterations among climate scientists, statisticians, and users should result in refinements of methods in service to decision making.

P-GC2.4

Evaluation of Regional Climate Simulations for Water Resources and Air Quality Assessment

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We have developed and applied dynamical downscaling methods for generating regional scale information of climate variability and change. This presentation will focus on evaluation of regional climate simulations for the U.S. at time scales ranging from diurnal to seasonal and interannual, emphasizing the hydrological cycle including different aspects of precipitation characteristics and extreme events. These include simulations driven by global reanalyses and global climate simulations. The downscaled and global simulations will be contrasted to examine the value added by dynamical downscaling. Projections of future climate changes produced using dynamical downscaling of different global climate simulations will be discussed in the context of their applications to assessing water resources and air quality impacts, and to elucidate uncertainties. Lastly, prospects for new developments in regional climate modeling and their relevance to addressing model bias and interdisciplinary issues important to the society will be discussed.

P-GC2.5

The North American Regional Climate Change Assessment Program (NARCCAP): Multiple AOGCM and RCM Climate Scenario Projections for North America

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The North American Regional Climate Change Assessment Program is using an ensemble of global and regional climate models (GCMs and RCMs) to produce downscaled estimates of changes in water and energy cycles decades into the future. The program plans to include the RCMs MM5, HadRM3P, RegCM3, the Canadian Regional Climate Model (CRCM), the NCEP Regional Spectral Model (RSM), and the Weather Research Forecast (WRF) model. The models are being driven by NCEP reanalyses and will eventually use output from several GCMs: potentially the Hadley Centre's HadCM3, the NCAR CCSM, the Canadian CGCM3 and the GFDL AOGCM. The resulting climate model runs will form the basis for multiple high-resolution climate scenarios to be used in climate change impacts assessments in the U.S. and Canada. High-resolution global time slice experiments using the GFDL AGCM and the NCAR AGCM CAM3 will also be produced and compared with runs of the regional models. The collective analysis of output from multiple models provides a framework for projecting climate change and its uncertainty over multiple time scales.

Initial results show precipitation and temperature biases that are comparable to those seen in previous regional simulations, even though the program is using a large domain covering most of North America. Perhaps most important, model output indicates that the collection of all models produces a more complete depiction of the uncertainty in estimating precipitation change than could be obtained from a single model.

P-GC2.6

Observed and Modeled Climate Variability over the United States Associated With Major Teleconnection Patterns

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Atmospheric circulation patterns and their connections to surface conditions are among the primary influences on climate and variability over the U.S. As climate is expected to continue to change in the future in response to emissions from human activities, the need for informed decision making based on the latest understanding of climate and how it is changing is likely to become even more urgent.

Here we first assess historical observed surface temperature and precipitation variability associated with six major atmospheric teleconnection patterns that affect surface conditions across the continental U.S., including the El Niño-Southern Oscillation and the North Atlantic Oscillation. We next evaluate the ability of four atmosphere-ocean general circulation models commonly used to produce simulations of future climate (PCM, HadCM3, CCSM and GFDL) to reproduce historic atmospheric circulation patterns and variability, as defined by the standard indices based on pressure, geopotential heights, winds, and sea surface temperatures. Model ability to simulate the teleconnection patterns in terms of the temporal frequency of index itself as well as the sign and magnitude of their influence on regional-scale temperature and precipitation has important implications for the ability of these models to simulate climate and climate change over these regions. Finally, we assess projected changes major teleconnection patterns under conditions of future change as simulated for the SRES A2 (mid-high) and B1 (lower) scenarios to demonstrate how these are likely to continue to influence climate over the continental U.S. in the coming century.

P-GC2.7

Providing Climate Information Across a Continuum of Time Scales

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Climate-related decisions may be made with time horizons ranging from weeks to decades; decision-makers thus require useful predictive information on a correspondingly wide range of time scales. In the seasonal-to-interannual (SI) domain, ENSO drives climate variability in many parts of the world, providing a basis for prediction. At the other end of the spectrum, on centennial time scales, coupled atmosphere-ocean general circulation models (AOGCMs) may have something useful to say as well. However, given the intermediate time horizons on which many decisions are made, typically years, out to one or two decades, neither ENSO-based predictions nor the long-range climate projections provided by AOGCMs may provide appropriate guidance. The present work addresses this gap in available forecast products and tools.

Secular changes in climate are part of the "big picture" that decision-makers must assimilate as they look forward in time. Such changes are not experienced separately, however, but constitute only one component within the full spectrum of climate variability. Providers of climate information must therefore take variability across a range of time scales into account, these time scales in turn informing a range of forecast products. These products may derive from different kinds of predictions or even different prediction tools.

It is the goal of the International Research Institute to provide climate information in support of decision processes on a continuum of time scales, with a focus on developing countries. In this regard, collaborative work in Brazil, regarding water resources and economic development, is discussed. Here, a "layering" approach is adopted, in which secular variation is taken as a context for the interpretation of SI forecasts. Decisions can then be informed by a fully dynamic view of climate variability. The underlying philosophy considers multi-model climate change outlooks and probabilistic decadal predictions as a background against which response to SI forecasts may be considered, in the context of long-term planning.

P-GC2.8

Needed: A National Policy in Regard to Climate Modeling

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In most fields of science, when a theory or model disagrees with observation the theory or model is considered to be wrong and is not taken seriously. This is not the case in the field of climatology. Consider the following example: Douglass *et al*. [1] published a paper: Altitude dependence of atmospheric temperature trends: Climate models versus observation in which they stated: "… all state-of-the-art general circulation models predict a positive temperature trend that is greater for the troposphere than the surface. … the temperature trends from observational data sets … show decreasing values." This devastating result has been ignored along with other such observations.

There is no accountability.

A new paradigm is needed.

Climate modeling began with individuals [Lorenz on a Royal McBee LGP-300] and has progressed to large groups [more than 20 worldwide] with super-computers. The magnitude of the funding and the uncritical publicity surrounding certain extreme predictions have catapulted climate science into a position of national importance to such an extent that policy makers are keenly interested in the results. These models represent a national resource that has attained a status comparable to that of a mission pursued at national facilities [telescopes, nuclear accelerators] and should be recognized as such. Future use of these climate models requires a new paradigm. At present, scientists:

- Build the models and also
- Determine policy in the use of the models results.

To insure accountability and reduce conflicts of interest these two functions should be separated as they are in other most other scientific fields of national interest (nuclear physics, astronomy, etc.). The model builders can not possibly conceive of or understand the full implications of the use of the models. The models and the use of the model results should be recognized as separate and independent.

Recommendation

The new paradigm calls for the creation of a committee or commission, a continuing body with rotating membership with no more than half from the climate community. A possible mission statement could include:

- Establishing national guidelines
- A mechanism to insure honesty and scientific integrity
- Oversee and make policy such as
  - 30% of each models time must go to outside scientists with a mechanism to ensure success in their use of the models
  - Strategy in the use of all model results
- Setting up subcommittees with power, such as an "experiment selection committee"

[1]Douglass, Pearson and Singer. GEOPHYS. RES. LET., VOL. 31, L13208, doi:10.1029/2004GL020103

P-GC2.9

A Closer Look at Sea Surface Temperature (SST) Trends

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We examine here the fundamental physics of SS heating by short-wave (SW) and long-wave (LW) radiation. Solar SW radiation penetrates to some considerable depth, depending on wavelength and turbidity. With an average ocean albedo of 0.09, most of the visible part of the solar spectrum heats the euphotic zone, and through wave action and eddy mixing communicates this energy downward, heating the "mixed layer," conventionally taken as the upper 100 meters. But LW (atmospheric) radiation, typically around 10 microns, cannot penetrate into water beyond a "skin" of about 10-micron thickness. As a result, the enhanced (anthropogenic) greenhouse effect from an increase in GH gases may make only a minor contribution to SST. Thus SST should not warm appreciably in response to the anthropogenic GH effect.

The absorbed IR energy goes partly into radiation and partly into sensible and latent heating of the atmosphere. The processes involved cannot be reliably calculated. In order to discover what fraction of downwelling IR contributes to SST, one must carry out a measurement program in which the downwelling IR flux varies. We describe such an experiment.

But SST records of the past 25 years (referring to temperature of the mixed layer) do show an increase, comparable to that of land data. This temperature rise has conventionally been ascribed to GH warming.

To account for the obvious disparity, we examine more closely the types of measurements that make up the SST. They consist principally of temperature data from engine-cooling water measured at ship inlets (typically around 10 meter depth and below the euphotic zone) and—since 1980—an increasing amount of data from drifter buoys in the (warmer) euphotic zone.

We hypothesize that the reported SST warming is largely an artifact of the increasing percentage of (higher-temperature) buoy data. We also suggest various tests for falsifying the hypothesis.

Supporting the hypothesis is the reported disparity between surface and atmospheric temperature trends in the tropics [Douglass, Pearson, Singer, GRL 2004]. We suggest that the SST rise observed prior to 1940 is real but not caused by GH warming.

P-GC2.10

Issues for Use of Climate Models to Inform Policymakers, Assess Impacts, and Develop Adaptive Strategies

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Take-Home Messages:

1) Impact assessment and scenario development must approach climate model output far more critically, conducting expert and thorough historical record validation of all critical aspects of the problem as a first mandatory step.
   Otherwise the assessments or scenarios may be worthless or, worse, misleading.
2) Model validation needs greater research attention, both to meet user needs under (1) and to sensitize modelers to deficiencies.
   Currently, model validation is grossly inadequate.
3) More attention needs to be paid to the development of credible mesoscale (to avoid downscaling compromises) global coupled models that correctly treat the full spectrum of variability.
   Downscaling (whether statistical or with nested models) is inherently flawed.

Discussion:

Global climate change will not be uniform either geographically or seasonally. Associated changes will not only be in temperature means but in its variability, both intraseasonal and interannual, in the means and variability of precipitation, winds, etc. and in the risks of high impact weather types and events. It is rare that a policymaker, adaptive planner, or resource manager concerned with climate sensitive issues or sectors should not have a critical interest in this granularity of change, certainly at a minimum the seasonal and geographic distribution of changes in the mean temperature and precipitation; changes in the mean annual global surface temperature are of no practical interest to anyone by themselves.

Unfortunately, state-of-the-art climate models that credibly product the historical trace of the global mean annual temperature also credibly reproduce at best the geographic distribution of mean temperature trends in some, but not all, seasons. Major deficiencies remain in historical simulations of some aspects of mean temperature changes and all aspects of mean precipitation changes, while little or no attention has been paid to validation of variability, extremes, etc. and their changes. The ability of these models to credibly treat much of the latter depends on their ability to reproduce the form, seasonality, and variance of the phenomenon that constitute the dominant controls on weather systems and their variability. These phenomena minimally include ENSO, the MJO, and the NAO. Since no climate model has been shown to collectively and correctly treat all three it is unlikely that any model can currently and credibly address variability or risks of high impact events. Because of these and other deficiencies, downscaling (whether statistical or dynamical) based on perfect model approaches cannot be a productive approach to scenario development in almost all instances. Correction approaches are problematic as well because of data limitations and the inherent non-stationarity of climate change.

P-GC2.11

Towards Interoperability of Global Geospatial Data Sets: Discrete Global Grids

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This research addresses a fundamental information infrastructure issue as it relates to climate modeling: the interoperability of geospatial data sets on a global scale, and their analysis using a globally distributed computational network. The focus of the research is on advances in the computational support for hexagonal discrete global grids (DGGs), and the rationale for their adoption.

It might be asked why there is a need to impose a grid of any kind on the Earth's surface, if the application merely needs to record the location (lat/long) of a global set of geospatial objects. At the application modeling level there may well be no such need, but it is a basic requirement at the computational modeling level. It comes down to the efficiency of sorting, searching and dynamic data organization. Ultimately, in order to achieve the twin objectives of logarithmic access time and a guaranteed minimum overall memory occupancy, data must be stored in indexed buckets (which in practice are usually disk blocks). And efficient indexing requires that there is a direct mapping from a geospatial reference (lat/long) to a specific bucket. But all these requirements cannot be simultaneously satisfied with a one-to-one mapping between indexed buckets and a disjoint set of lat/long grid partitions (most familiarly, the grid of squares defined by equal increments of latitude and longitude on a Mercator projection).

Applications involving modeling of dynamic flows over the Earth's surface or upper atmosphere impose the further requirement that grid partitions are of equal area and as far as possible have the same shape. And their adjacency properties with directly neighboring partitions should be the same for all of them. These requirements cannot be satisfied by any rectangular grid, and demand direct computation on the surface of the spheroid.

Over the past ten years this has led a small group of mathematicians and geographers to develop promising new spherical data models based on DGGs. But they have run into performance problems because of the limitations of the indexing techniques currently available. Yet at the same time, within the spatial database research community, there have been significant advances in multidimensional indexing techniques with improved performance, and with properties which appear to be ideally suited to the support of such DGGs. This poster presents the basic concepts involved, and emphasize the advantages of a canonical global grid structure in facilitating computations between global data sets.

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