Issue 9 November/December 1999

Acclimations

Newsletter of the U. S. National Assessment of Climate Variability and Change

Indirect and Manifold Effects . . .

By Michael W. Slimak, Associate Director for Ecology, National Center for Environmental Assessment, U.S. Environmental Protection Agency and member of the Subcommittee on Global Change Research

"Indirect and Manifold Effects . . .," These are the words used by Dr. J. Alan Pounds as he described the biological response to climate change on a tropical mountain ecosystem (see Nature Vol 398; April 1999). His recent presentation at the monthly USGCRP Seminar Series on the extinction of the Golden Toad and the link to a rise in the orographic cloud bank in Costa Rica is an excellent example of the "indirect and manifold effects" that must be considered in assessing the consequences of climate change and variability on ecosystems. While we tend to focus on the direct effects of climate change because establishing a stress-response relationship is at the heart of an assessment, much of the effects on ecosystems will be indirect and manifold; i.e., of many kinds and multiples. It is essential that as we assess the consequences of climate change on ecosystems that we explicitly build the notion that the effects are "indirect and manifold" into the design of the research, the collection of data, and the formulation of assessments. An example of the indirect and manifold effects involves non-native invasive species. Climate change may result in a longer growing season, which may give some invading weedy plants time to flower and set seed where previously they could only spread asexually. This newfound ability to flower could have profound implications for not only the invader but for those organisms associated with the invading species. Certain invading weeds like cheatgrass (*Bromus tectorum*), which dominates vast areas of the American West, appear to adapt more quickly to rising levels of carbon dioxide in the atmosphere than native species.

We know that ecosystems already face a wide range of stresses: e.g., habitat destruction and fragmentation; loss of species; invading non-native species; changes in the nutrient cycles; and xenobiotic chemicals. Assessments need to be conducted that not only incorporate information on global environmental change, other stresses, ecosystem functioning and biodiversity, but that also include social and economic factors and responses. Perhaps the biggest challenge in conducting assessments on ecosystems is in answering the "So what?" question. Most people agree on the value of protecting human lives and improving conditions of human health. Human health assessments deal with effects already familiar to the public, such as cancer rates and birth defects, and the debate rarely is about the importance of these effects. Ecological assessors, however, are faced with assessing effects (or endpoints) driven by ecological values that are poorly understood by the public. Despite the "So what?" problem, the practice of ecological assessments has become inculcated into the operations of regulatory agencies, the regulated sector and non-governmental interest groups. This evolution of the practice and the science of assessments has led to a better understanding of how cause-effect relationships of stressors and receptors are analyzed and quantified. It requires that our assessments be structured to account for the "indirect and manifold" effects in a way that minimizes the debate about the scientific plausibility of the assessment while focusing more on what to do about the consequences.

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[acclimation, noun; "Adjustments to a changing environment"; Roget's Thesaurus]

Southeast Regional Assessment Status

By Ronald L. Ritschard, University of Alabama, Huntsville

Using input from the June 1997 Southeast Regional Scoping workshop and follow-on meetings with other regional stakeholders, an interdisciplinary research team was organized to conduct a Regional Assessment of the implications of climate variability and change on agriculture, forests, environmental quality (air and water), and the cross-cutting implications of water resources on these sectors. The assessment team includes researchers from Auburn University, Florida State University, North Carolina State University, Research Triangle Institute, University of Alabama (in Tuscaloosa and Huntsville), University of Florida, US Forest Service, and USDA's Peanut Research Laboratory. The team also works closely with the Southern Growth Policies Board, Appalachian Regional Commission, state and local government agencies (i.e., Alabama Department of Economic Affairs), utility companies, and with the agricultural extension in several southeastern states. It is anticipated that these stakeholder relationships will be enhanced in the future as assessment results and new analytical methods and data become available. A brief summary of our progress to date is provided in Figure 1.

Agriculture

Crop yield simulations with the Hadley (HadCM2) climate scenarios for the decades around 2030 and 2090 were performed using current management conditions for six key crops (corn, peanut, rice, soybean, sorghum, and winter wheat). County-level yield results and irrigation demand by crop were estimated for the entire southeastern US. As shown in Figure 1, there is considerable variability among crops with regard to their sensitivity to climate variations. Corn and sorghum, for example are particularly sensitive to higher temperatures. These maps also show the spatial variability in crop response across the Southeast. Preliminary results indicate that most negative effects are found in the Gulf Coast region. These crop responses will also be used in a USDA/ARS regional farm management model (PNTPLAN) to determine how farm managers might respond. Farm management optimization is being run for these crops using the climate-induced yield changes for 2030 and 2090 assuming a representative 200-acre farm with current crop mix and crop yield for each county. A full set of results for all locations and all six crops is expected by the end of 1999.

Forestry

As part of the regional assessment, the Hadley (HadCM2) climate scenarios were also applied to a forest productivity model (PnET-II) across the southeastern states. This forest process model combines climate, soil, and vegetation data to predict productivity, soil water stress, and drainage. Figure 2 shows results for pine and southern hardwoods comparing baseline conditions (2000) to 2090. Under baseline conditions southern pine productivity would be approximately 5% less than hardwood productivity, but by 2090 hardwoods would be about 27% more productive than pine forests across the southeast region. Pines have greater water demands than do hardwoods on an annual basis. Even with the increased water use efficiencies associated with increased atmospheric CO2, the southern pines are limited by water as evapotranspiration rates increase with air temperatures.

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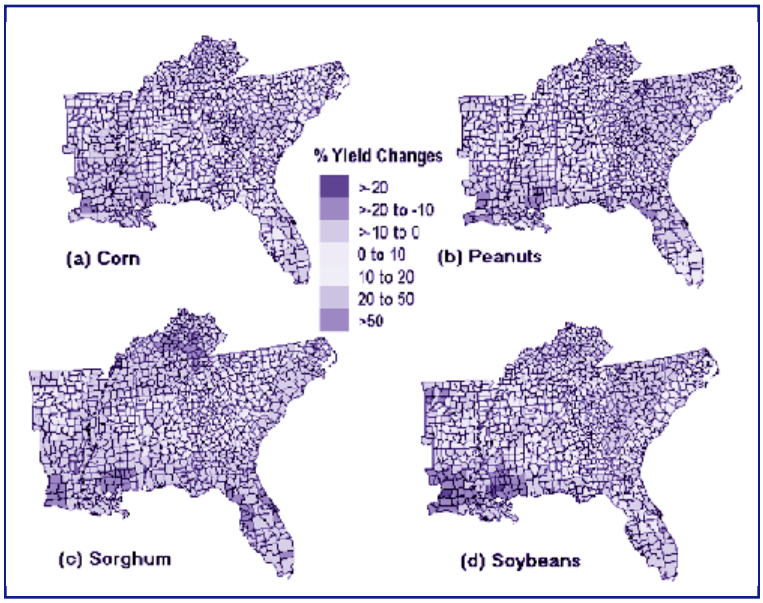

Figure 1a - Projected chages in 30-year averaged rainfed yields of crops in the Southeast by 2030 using VEMAP Hadley climate scenario.

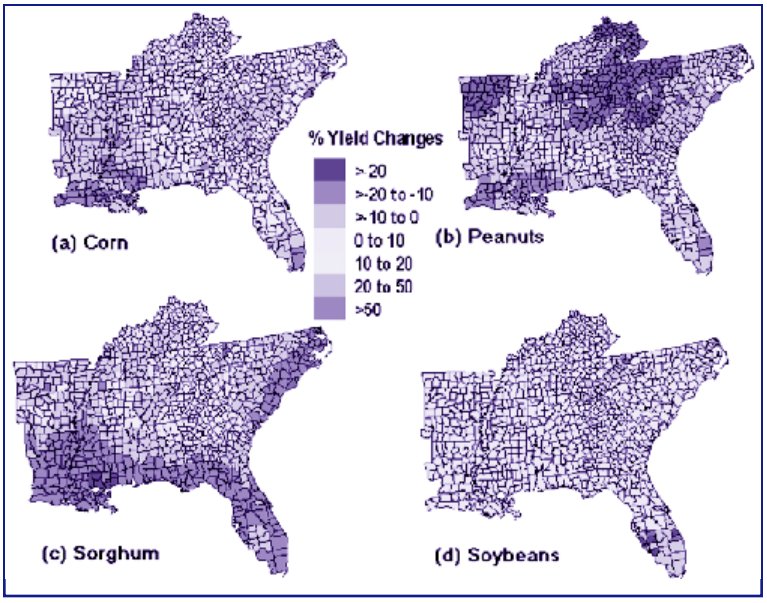

Figure 1b - Projected chages in 30-year averaged rainfed yields of crops in the Southeast by 2090 using VEMAP Hadley climate scenario.

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These responses, however, could likely be ameliorated since pine plantation managers would be able to adapt silvicultural techniques and species composition in response to climate change. The forest productivity results are being linked to the Sub-Regional Timber Supply model. This economic model uses relationships between prices, harvest, and inventory to suggest the market effects of shifts in supply or demand.

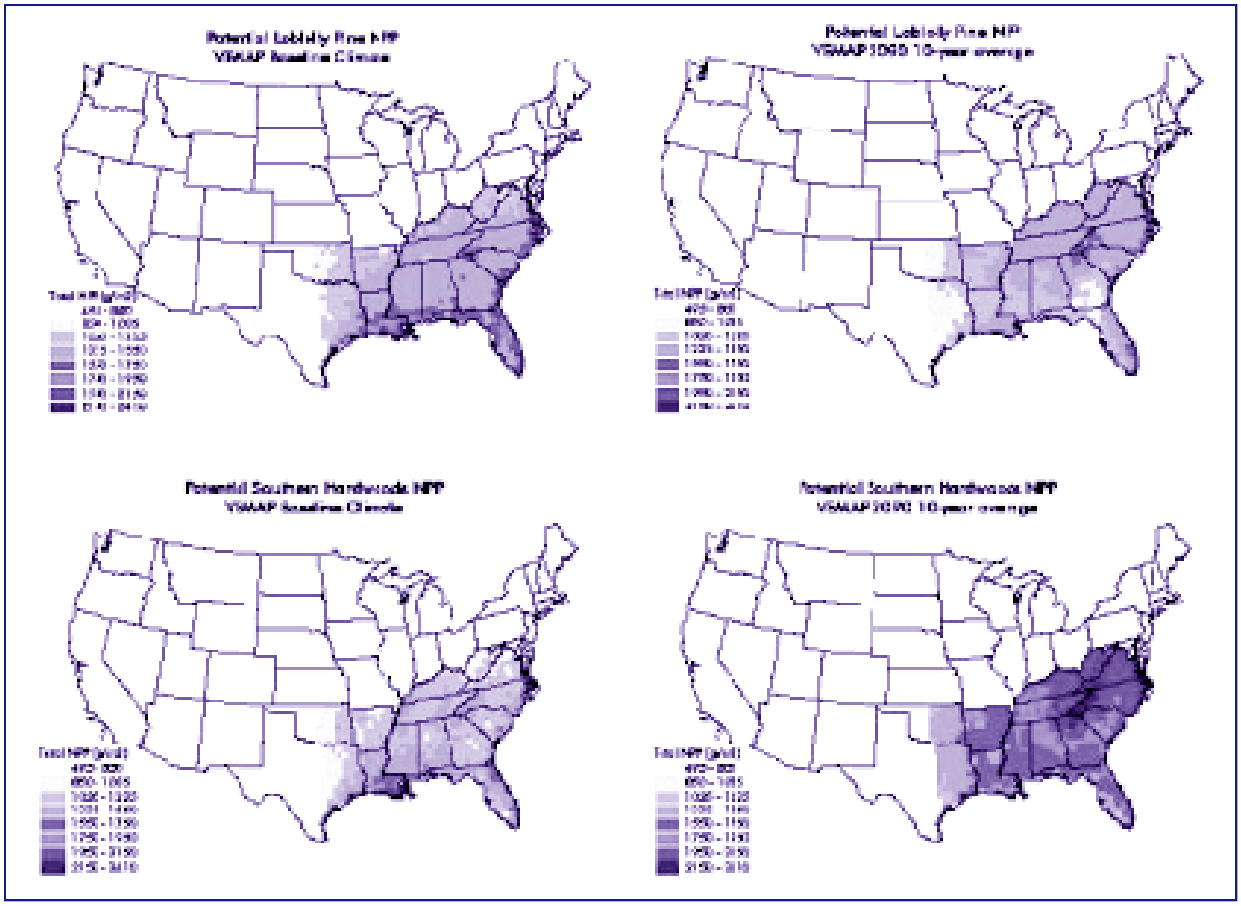

Figure 2 - Forest productivity model (PnET-II) results for pine and southern hardwoods.

We expect these economic results will become available over the next few months.-Figure 2 - Forest productivity model (PnET-II) results for pine and southern hardwoods.

Water Quality

An assessment of southeastern water quality associated with changes in climate was conducted using EPA's GIS-based BASINS model to evaluate current and future water quality conditions under both mean and extreme hydologic conditions. The Hadley climate scenarios show significantly decreased precipitation during the first six months of the year with rainfall returning to normal, or near normal, for the last six months, particularly by the end of the century. These results are particularly striking for the Gulf Coast region and appear to indicate that this area may be exceptionally vulnerable to degraded conditions during the first half of the next century. Preliminary hydrologic analyses based on the Hadley (HadCM2) model predictions appear to confirm that streamflow in the Southeast (particularly along the Gulf Coast) will decline during the early summer months over the next 30 years. These results suggest that water quality conditions in this region may become critical during the more frequent periods of extreme low flow. Correlation of the hydrologic analyses with the land use in basins where water quality (i.e., dissolved oxygen, nitrates) have already been identified reveals that the problems may be most acute in areas of intensive agricultural activity, or in coastal or near coastal streams.

Integration

The most innovative feature of this assessment is the application of an integrated approach that links climate variability and change with crop yields, regional economics, and forest productivity and timber markets. The results of these linkages will then be used in a land use model to estimate economic incentives for land use conversions between agricultural and forest lands. Over the next few months, the Southeast Regional Assessment team plans to complete these analyses and document the results in a summary regional report. The next step in the overall assessment process will be to transfer this new understanding to relevant stakeholders in the region through education, data interpretation, and introduction of simplified analytical tools and other products that can be incorporated into existing decision-making processes at the local and regional levels. Meetings are already being planned with several state and local government agencies and with representatives from the agricultural sector (i.e. agricultural extension, farm cooperators, agribusiness) to identify specific assessment products that can be applied to local, state, and regional problems.

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Central and Southern Appalachia: Balancing Many Demands

By Trina Karolchik Wafle, and William T. Peterjohn, West Virginia State University

Stakeholders in Central and Southern Appalachia are concerned with present and future changes in the natural environment, as well as to changes arising from policy decisions that may significantly affect the region's economy.

To identify those current stresses on the region that might be most vulnerable to climate variability and change, ninety-five people from nine states that comprise the central and southern portions of Appalachia met at West Virginia University in Morgantown, WV in May, 1998 for the Central and Southern Appalachian Regional Workshop. The purpose of this event was to begin to identify topics warranting further study should an assessment of the impacts of climate change on the region be undertaken. The event was sponsored by the USDA's Forest Service as one in a series of National Assessment regional workshops.

A subset of the area defined as Appalachia by the Appalachian Regional Commission (ARC) was used to establish the region for our workshop and to identify eligible participants. The region follows the Appalachian mountain range and includes east-central Pennsylvania, all of West Virginia, eastern Kentucky, eastern Tennessee, northern Alabama, northern Georgia, western North Carolina, southwestern Virginia, and western Maryland.

Participants in the workshop included academic and government scientists, industry representatives, environmental activists, and elected officials. Some were knowledgeable about the state of climate science and some were not. Experts from within and beyond the region presented plenary talks on the socio-economic characteristics of the region, climate science, national and regional energy patterns, regional forest health, and issues related to water resources and agriculture. While the event emphasized climate variability and change, for some groups, policies to address the potential for long-term climate change were equally important.

Appalachia is characterized by steep topography, serves as the headwaters for many of the major waterways in the eastern U.S., and has a rural population whose level of education is less than the national average. Half the counties in the whole of Appalachia reflect national economic trends. However, half the counties lag significantly behind the nation, with smaller and more remote counties experiencing poverty rates two-and-one-half times the national average. For example, double-digit unemployment is typical in southern West Virginia counties. Appalachia is more dependent on manufacturing than the nation as a whole. Indeed, the recent Southern Appalachia Assessment published in 1996 found that manufacturing alone accounted for 22.6% of the employment, 30.4% of employee compensation, and 39.8% of the industrial output. These industries are often significant energy consumers. Changes in commodity energy prices have had a much bigger impact on the central portion of the region than on the nation as a whole. The region also has a higher share of jobs in natural resource-related sectors, including coal mining and farming, than the nation as whole.

Topics discussed by the region's participants included human communities and health, water resources, forestry, agriculture, and energy.

Communities and Human Health: Workshop participants felt that national legislation to counter CO2 emissions from fossil fuels may significantly affect human communities in this region because coal mining is economically important to many distressed counties, and because the economic base of the region as a whole relies heavily on manufacturing. Recovery from severe weather events, especially in areas with aging or little infrastructure, was also cited as an important issue. While the most pressing health issues in the region (e.g., high rates of cancer, heart disease, and obesity) are not likely to be affected by climate variability or change, health concerns related to climate may include:

- effects of declining air quality made worse by stagnant air masses which trap airborne pollutants and a lack of a perceived threat among people who believe the air is cleaner than it is,
- declining water quality and quantity in a region where the population relies heavily on well water and where sewage overflows and other sources of contamination seem to be prevalent;
- climate-related increases in rodent and insect populations that carry infectious diseases, the introduction of new diseases, and biological changes that promote the emergence and spread of disease;
- an increase in the frequency and severity of natural disasters in a region where victims receive less economic and social support;
- and an increase in urban sprawl and a lack of land-use planning that could worsen the effects current and future climate variability.

Water Resources: Central and Southern Appalachia is highly susceptible to soil erosion and valley flooding. The four most important concerns mentioned during the workshop were:

- changes in the distribution of precipitation in time and space (e.g., the frequency and extent of large rain events and droughts) and its effects on soil moisture, erosion, landslide hazards, flood control, flood prediction, and adequate flood warning;
- changes in water quality (especially temperature) and quantity, and their impact on sensitive species and species that are already threatened and endangered;
- increased water removal from surface and ground water supplies by human activities and evapotranspiration; and
- changes in water temperatures and their impact on power generation

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Forestry: Over 70% of the region's landscape is forested, with the related wood-products industry playing an increasingly important role in the region's economy. For example, the industry has provided 70,000 stable jobs in the southern part of the region between 1975-1993. Issues relevant to climate concerns include:

- alterations in the composition of tree species present in the forests;
- sustainable forest productivity and health in the face of increased nitrogen deposition, greater ozone concentrations, higher levels of CO2, drought, and warmer temperatures;
- the climate sensitivity of native and introduced species (including plant pathogens);the effects on water quality due to changes in soil erosion, nitrogen concentrations, etc.;
- the interactive effect of climate change and forest management on stream flow and flooding events;
- and changes in the susceptibility to and frequency of fire.

Agriculture: Regional features that make agriculture particularly vulnerable to climate variability and change include farming in valley bottoms, narrow economic profit margins, the use of longer-lived perennial crops for some farmers (e.g., fruit trees), and susceptibility to soil erosion. Among the top climate-related concerns were the effects of drought, water availability for irrigation, soil quality, pesticide use, nutrient management, changes in pest populations, flooding, and water quality issues.

Energy: In 1995 for the U.S., 1,635 million metric tonnes of carbon were reportedly emitted into the atmosphere as a result of human activity, with 86% of those emissions attributable to fossil fuels, 30% from coal and 20% from natural gas, both important to the region. Of the amount released, 33% was due to energy consumption by industry, 30% by buildings, and 28% by transportation. Nine percent was attributable to municipal solid waste and agriculture and forestry activity. Coal is the dominant fuel for electricity generation. Data are not available solely for the workshop region; however, for the nine states, parts of which comprise the region, coal fueled 75% of the electricity generated. While coal is mined in each of the states in the region, Kentucky and West Virginia regularly jockey as one of the top three coal producers in the nation. Direct climate impacts on the energy sector, such as extreme weather events, are likely to be manageable. However, policies to deal with potential long-term climate change could have a major effect on the energy sector and on the economy of the region.

The observations listed for each of these areas would provide the basis for further study to firmly establish whether and what type of climate variability or long term changes would in fact severely stress the region.

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Second IAI/UM Summer Institute to be Held on Interdisciplinary Science in the Americas

The Inter-American Institute for Global Change Research (IAI) and the University of Miami (UM) announce the Second IAI/UM Summer Institute, to be held in Miami from July 16 to August 4, 2000. The theme selected for this year's Institute is "Environmental and social implications of land-use and land-cover change in the Americas". The Institute will explore the dynamics and interactions of land-use and land-cover change as both major inputs to, and consequences of, global environmental change. Land-use and land-cover changes have major implications for sustainable development and livelihood systems in the Americas. The Institute's theme will be explored from a multidisciplinary perspective, including both its natural and social dimensions. A preliminary program for the second Institute, as well as a list of instructors and guest lecturers will be released in late 1999. General background on the IAI/UM Summer Institute can be accessed through the WWW at http://www.rsmas.miami.edu/IAIUM.

Twenty applicants (approximately equal numbers of social and natural scientists) from IAI member countries will be selected to attend the Institute. Selected applicants will receive financial support covering travel to/from Miami, housing and meal expenses, and health insurance. Specific information on eligibility and selection criteria, as well as instructions on applying for participation will be available soon at the Institute's WWW site. In the meantime, potential applicants can register to receive further information as soon as it becomes available by filling out an electronic form at http://www.rsmas.miami.edu/IAIUM

Global Change Research at the Environmental Protection Agency

By Joel Scheraga and John Furlow, EPA

EPA's Global Change Research Program is an assessment-oriented research program with primary emphasis on understanding the potential consequences of global change for human health, ecosystems, and social well-being in the United States. Assessments are also being done of opportunities to adapt to change in order to reduce the risks and take advantage of opportunities that arise due to global change. Assessment is viewed as an ongoing process of synthesizing and analyzing the best available scientific and socioeconomic information in terms of its implications for policy, decision making, resource management, and society. In coordinating findings from diverse disciplines, assessment goes beyond simply reporting scientific findings about physical environmental effects and their causes. The physical or biological sciences are combined with the considerations of social scientists to attain a "policy-relevant" perspective, and to gain insights about different ways to achieve environmental improvements. Its purpose is to guide decision-makers and the public towards understanding the trade-offs among alternative risk management strategies.

Program Focus Areas

The Program assesses the potential effects of climate change and climate variability on: (1) human health; (2) air quality; (3) water quality and quantity; and (4) ecosystem health. Examples of research projects include assessments of:

- implications for the spread of infectious water- and vector-borne diseases;
- the mortality and morbidity effects of heat stress;
- ecological effects of UV radiation;
- effects of multiple stressors on Arctic ecosystems and human health;
- adaptive potential of ecosystems and species to current and future stresses;
- optimal water treatment regimes given expected changes in climate;
- effects on ecosystems and species of extreme events, including changes in frequency and intensity of droughts, floods, and temperature extremes;
- quantification of value of changes in ecosystems services;
- implications of sea-level rise for population displacement, damage to infrastructure, water quality, and human health.

All of the climate-induced changes are being assessed in the context of multiple stressors; that is, climate change is viewed as one of many stressors, including non-climate-related stressors. For example, the synergistic effects of climate change and UV-B exposure on ecosystems are being evaluated, as are the synergistic effects of climate change and land-use change.

The research and assessment activities are also evaluating the potential co-benefits of adaptation policies. Co-benefits refer to the collateral benefits that may accrue, for instance, when policies that result in reductions in criteria air pollutants also yield reductions in greenhouse gas emissions, or conversely, when policies aimed at reducing greenhouse gas emissions result in reductions in criteria air pollutants. The co-benefits to be examined include changes in emissions of criteria air pollutants, water quality changes, and improvements to ecosystem health. The resulting health and welfare effects of the changes in criteria air pollutants, water quality changes, and land-use changes are being assessed.

EPA's Role in the USGCRP National Assessment Process

EPAplays an integral part in the US Global Change Research Program (USGCRP), and is making significant contributions to the ongoing U.S. National Assessment process. In FY 2000, scientists supported by EPA's Global Change Research Program will complete the four assessments that EPA is sponsoring as part of the first National Assessment: the Mid-Atlantic Regional Assessment, the Great Lakes Regional Assessment, the Gulf Coast Regional Assessment, and the Health Sector Assessment. These assessments are being conducted through public-private partnerships that actively engage researchers from the academic community, decision makers, resource managers, and other affected stakeholders in the assessment process. The focus of each is as follows:

- **Gulf Coast –** The Gulf Coast Regional Assessment is analyzing the potential effects of climate change and variability on ecosystems, farming, forestry, industry, human health, air quality, water quality, fisheries, and recreation/tourism.
- **Great Lakes –** The Great Lakes Regional Assessment is considering the potential effects of climate change and variability on water quality and quantity, including lake levels and temperatures, storms and extreme events, natural resources, such as plant life, forests, wetlands, agriculture, air quality, health, and education.
- **Mid-Atlantic –** The Mid-Atlantic Regional Assessment is analyzing the potential effects of climate change and variability on forests, agriculture, water supplies, coastal zones, and human health.
- **Health Sector –** The Health Sector Assessment is analyzing the potential effects of climate change and variability on the health of the US population over the next 20 to 100 years.

Between 2000 and 2010, the EPA will continue to fulfill its commitments to the USGCRP and obligations under the Global Change Research Act of 1990 to conduct periodic scientific assessments of the regional consequences of global change for the United States. These assessments will be conducted in partnership with affected stakeholders in the regions to ensure that the insights gained will be useful and enable them to incorporate considerations of climate change into resource planning. Also, EPA's Global Change Research Program will continue to participate in and support the Intergovernmental Panel on Climate Change (IPCC) in the preparation of its periodic assessment reports. Outcomes from the program will be improvements to public health and ecosystem health as a result of more comprehensive resource planning by regional stakeholders.

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Canadian and Hadley Model Projections of Precipitation Changes for the 21st Century

By Benjamin Felzer, NCAR

A suite of tools have been developed for use by assessment teams, including scenario-driven simulations from the Canadian (CGCM1) and UK Hadley (HadCM2) general circulation models (GCMs) as one way to provide projections of climatic conditions in the 21st century. GCMs are physically based numerical models that utilize the fundamental laws of physics to describe motions and heat transfer in the atmosphere and ocean. Today's GCMs couple atmosphere, land surface, ocean, and sea ice to provide a comprehensive representation of the climate of the Earth. Simulations of 20th century climate include consideration of known changes in greenhouse gases and sulfur emissions, while scenarios of the 21st century employ projections of these emissions for the future. For the simulations chosen by the National Assessment, both CGCM1 and HadCM2 models are driven by a 1% per year compounded increase of the CO2 concentration (to represent the effects of all greenhouse gases), and by sulfur emissions that are projected to double by the end of the 21st century. These projections are consistent with the changes projected by the Intergovernmental Panel on Climate Change.

In response to the resulting changes in atmospheric composition, both models indicate that the climate will warm significantly, with global precipitation also increasing. For the National Assessment, the focus is on what is projected to happen over the United States. Maps of projected changes for the U.S. are viewable over the Web at http://www.cgd.ucar.edu/naco/vemap/trends.html.

The projected changes in precipitation over the US are of particular interest (Figure 1). Both models project large increases in precipitation in Southern California and the Southwest. However, the CGCM1 projects a decrease in precipitation in the Southeast while the HadCM2 projects an increase. Understanding why these changes, and these differences, are occurring is one step in seeking to project the consequences of climate change. This article focuses on key contributors to precipitation variations over the U.S.

Mid-latitude Storms

There are some robust signals of global warming that turn up in nearly all GCM simulations of the 21st century and that have particular consequences for storms (mid-latitude cyclones), especially during winter. With increased greenhouse gas concentrations, nearly all GCMs (including the CGCM1 and HadCM2) undergo enhanced warming at high latitudes in the lower atmosphere (because of sea ice-albedo feedback effects and weakening of the near-surface inversion); enhanced warming at low latitudes in the upper atmosphere (because of how vertical atmospheric structure in the tropics is determined); and greater warming over the land than over the ocean (because of evaporation, vertical mixing of heat and the ocean's larger heat capacity). The number of storms globally is dependent upon, among other factors, the temperature change between the pole and equator; the strength of storms is dependent upon the amount of moisture in the atmosphere. A smaller pole-equator temperature gradient results in fewer mid-latitude storms, while more moisture in the atmosphere provides more energy for storms that do occur.

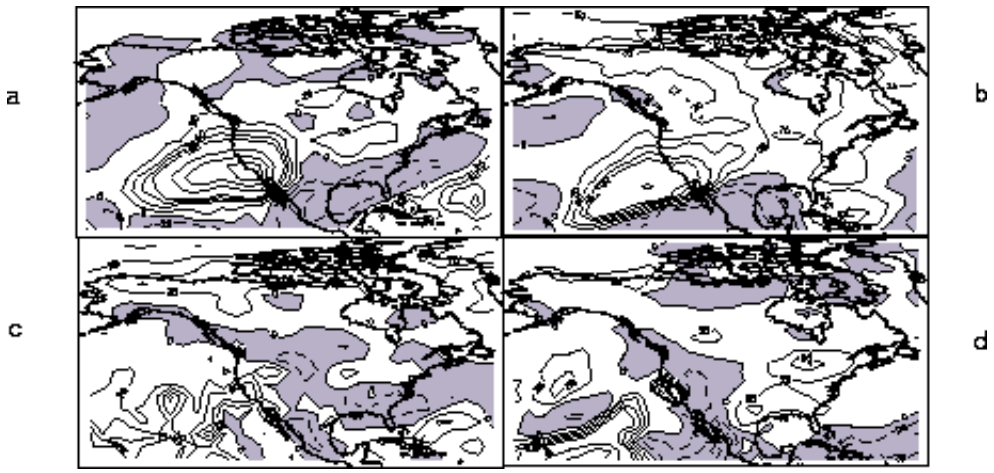

Figure 1: North American precipitation percent differences [((future - modern)/modern) * 100]. a) DJF, CGCM1, b) DJF HadCM2, c) JJA, CGCM1, and d) JJA, HadCM2. Shading indicates decreases in precipitation (percentages less than 0). The future period is taken as 2090-2099 and the modern as 1961-1990.

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Furthermore, the region of storm formation off the East Coast of the U.S. is locally dependent upon the land-sea temperature gradient. Warm Gulf Stream waters and a cold land surface in winter provide ideal conditions for generating many storms. With warming of the land surface in winter, the intensity of these storms could be reduced. Both models confirm a decrease in the number of East Coast storms, though some individual storms appear to be more intense. However, recent studies have shown that there is no decrease in East Coast storms over the past 100 years, but rather an increase through the 1960s.So what causes the different precipitation anomaly patterns that the two models project for the Southeast? One contributing cause is the difference between the two models in their projection of the position of the East Coast storm track. While the storms in HadCM2 track further north and east over the Atlantic Ocean, the storms in CGCM1 track closely along the coast itself. As a result, even though both models show a decrease in the number of storms along the East Coast, the effect of that decrease is felt over the U.S. only in the CGCM1 model. Observations indicate that the storm tracks should extend along the southeastern coast of the U.S., so in this particular region, they are more accurately located in CGCM1, although they are overrepresented to the south.

ENSO

El Nino/Southern Oscillation (ENSO) is a major driver of the tropical and global circulation. During warm ENSO events (El Nino), the waters off the coast of Peru warm up, changing the atmospheric and oceanic circulation in the Pacific region. These changes then affect global weather patterns and the position of the jet stream over North America. Although the effects of global warming on ENSO are highly uncertain because of the limited ability of GCMs to simulate ENSO variability, some models, including the CGCM1, suggest the possibility of a more persistent El Nino state. Regardless, both models produce a stronger Aleutian low and a weaker subtropical high over the Pacific, which may be the result of a warm ENSO phase (El Nino). Together, these circulation changes along with warmer sea surface temperatures (SSTs) are associated with an increase in storms that penetrate inland further south along the West Coast. It is thus not surprising that the precipitation changes projected by the models include a large swath of increased rainfall projected over the eastern Pacific Ocean, extending into the southwestern part of North America.

Land Surface

Many of the precipitation changes in the GCMs, particularly during summer when the atmospheric circulation is weaker, are the result of feedbacks from the land surface. During winter, snow cover is the mechanism for this interaction, while during summer, soil moisture is most important. Over the ocean, warming generally correlates with increased precipitation because there is greater evaporation. However, because of the limited moisture-holding capacity of land, warming over land may lead to increased or reduced precipitation, depending on a range of factors such as how soil moisture budgets are calculated. Soil moisture anomalies generally correlate with precipitation anomalies during winter. During summer, however, the increase in evaporation is sometimes enough to cause drying even in areas that get more precipitation than present, which could then limit the amount of additional precipitation. Vegetation is another important feature of the land surface, although human-induced reductions in future vegetation cover are not yet being treated in climate models.

Lessons

These examples illustrate the importance of careful analysis and taking proper cautions when interpreting results from GCMs. The storm track analysis of model results shows that the same physical mechanism can lead to opposite outcomes when imposed on a slightly different base state. The uncertainty in predictions of changes in ENSO variability also necessitates caution in projecting the nature of future changes in ENSO or the resulting effects of those changes on North America.

Even with these and related limitations, however, there is good reason to believe that there will be significant changes in precipitation, and thence in the availability of water resources. The implications of these changes in precipitation are explored in detail in the water resources sector of the National Assessment.

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Reviewers Sought for Assessment Reports

Review of the reports being prepared for the National Assessment is an important aspect of ensuring both their credibility and relevance for the Nation. To ensure a thorough review, nominations were solicited for expert reviewers to comment on the various sections of the report. National Assessment stakeholders were invited to volunteer to participate or to nominate others who could serve as expert reviewers.

The first stage of the review process, expected to take place starting in mid-November, is a technical review of the various parts of the Synthesis Team's foundation report and the incorporation of these findings into a draft overview report.

There will be a second opportunity for review of the report during a public comment period planned to begin early next year. For that review, a draft of the report will be posted on the Web and public comment will be invited from a wide range of reviewers (including interested scientists, stakeholders, government leaders, representatives of public and private organizations, etc.).

Those unable to participate in the technical review round are invited to indicate their interest in being informed of the public review by sending email to climate@usgcrp.gov

Calendar

National Assessment Sponsored Meetings:

Pacific Northwest: Release of Regional Assessment Report
Seattle, WA
November 9, 1999
(Contact: Adrienne Karpov, karpov@u.washington.edu)

Climate Change: Meeting the Challenge/Seizing the Opportunities
Upper Midwest Aerospace Consortium (UMAC)
November 15-16, 1999
(For further information: www.umac.org/climate/1999workshop; or contact: Leigh Welling, lwelling@aero.und.edu)

National Assessment Synthesis Team Meeting
San Francisco, CA
December 15-16, 1999
(Contact: Melissa Taylor, mtaylor@usgcrp.gov)

Related Meetings:

Technical Symposium on Global Warming
American Nuclear Society 1999 Winter Meeting
Long Beach, CA
November 14-18, 1999
(For more information, http://www.ans.org/meetings/)

First Annual Worldwide GIS Day
November 19, 1999
(For more information, http://www.gisday.com/)

American Water Resources Association's Annual Water Resources Conference
Seattle, WA
December 5-9, 1999
(Contact: e-mail: awrahq@aol.com or tel: 703-904-1225).

Groundwater: ATransboundary, Strategic and Geopolitical Resource, Association of Ground Water Scientists & Engineers Technical Program
Las Vegas, Nevada
December 13-16, 1999
(Contact: Michael E. Campana, aquadoc@unm.edu; 505-277-3269; Fax: 505-277-3269)

American Meteorological Society: 11th Symposium on Global Change Studies
Long Beach, CA
January 9-14, 2000
(For more information: http://www.ametsoc.org/AMS/meet/1999meet_hp.html)

American Association for the Advancement of Science Annual Meeting and Science Innovation Exposition
Washington, DC
February 17-22, 2000
(For more information: http://www.aaas.org.meetings)

World Water Forum
The Hague, The Netherlands.
March (TBD), 2000
(Contact: B.J.P.M. Claassens, WWF@europortmedia.com)

Association of American Geographers Annual Meeting: Biosphere-Atmosphere Interactions
Pittsburgh, PA
April 4-8, 2000
(For more information: http://www.aag.org/AnnualMeetings/Intro.html)

The XI Global Warming International Conference & Exposition
April 25-28, 2000
(Contact: GWXI International Program Committee, Expo Coordinator, SUPCON International, PW Box 5275, Woodbridge IL 60517-0275, Fax: 630-910-1561)

American Water Resources Association: Water Resources in Extreme Environments
April 30-May 4, 2000
(Contact: Mike Kowalski, 540-687-8395 or mike@awra.org)

Second National Extension Natural Resources Conference: "Excellence through Partnerships"
Stateline, Nevada (South Lake Tahoe)
May 16 - 18, 2000
(Contact: Rick Standiford, University of California Center for Forestry, 510-643-5428 or standifo@nature.berkeley.edu)

International Conference on Climate Change Communication
Kitchener-Waterloo, Ontario, Canada
June 22 - 24, 2000
(For more information: http://geognt.uwaterloo.ca/c3confer/; or send email to: c3confer@fes.uwaterloo.ca)

Second Inter-American and University of Miami Summer Institute
Miami, FL
July 16-August 4, 2000
(For more information: http://www.rsmas.miami.edu/IAIUM)

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