# Exceptional Service Award for Protecting the Environment



DOE's Biological and Environmental Research (BER) program originally focused on understanding the fate, transport, and transformation of airborne radioisotopes released during nuclear weapons testing and production. Other studies examined the ecological impacts and processes that cycle radioactivity through plants and animals to humans. Now, evolving research is directed toward understanding the basic chemical, physical, and biological processes of the earth's atmosphere, land, and oceans and toward developing new methods for remediating the nation's nuclear weapons testing and production sites.

## Global Climate Change

Research is conducted to understand and predict global climate change and the potential ecological consequences that may result from energy-related aerosols and greenhouse gases. BER climate-change research and modeling studies include exploration of factors affecting the earth's radiant-energy balance and seek to quantify sources and sinks of energy-related greenhouse gases, especially carbon dioxide. This ongoing research is a vigorous priority for BER and its interagency partners in the U.S. Global Change Research Program.

## Environmental Remediation

BER's Environmental Remediation portfolio is developing more effective and efficient processes for cleaning up soils, sediments, and groundwater contaminated by nuclear weapons production and testing. Among the means available for reclaiming the environment are the tools of molecular biology. The first forays into bioremediation—the use of biological processes to address the problems of waste management—began in the late 1960s with attempts to harness microbes to clean up wastes from coal conversion reactions and nuclear materials processing.

The successful BER subsurface science program that explored the deep subsurface environment for microorganisms, coupled with new strategies and technologies arising from the Human Genome Project, allowed BER to initiate the Microbial Genome Project (MGP) in the mid-1990s. MGP investigators are studying microbes that are or could be important for solving bioremediation challenges and serving other economic and industrial interests. Analysis of the genomes of these microbes is providing insights into how they survive, especially under extreme conditions, and will afford opportunities to exploit biochemical mechanisms and pathways not expressed in higher organisms.

With the establishment of the Natural and Accelerated Bioremediation Research (NABIR) program in 1995, BER has sought to build on the foundation laid by subsurface science research, bringing together geologists, chemists, biochemists, molecular and cellular biologists, microbiologists, and ecologists. NABIR-funded researchers conduct laboratory studies, field studies at contaminated sites, and theoretical research to enhance the scientific basis for using bioremediation to restore and protect the environment.

A key part of BER's commitment to environmental restoration resides in the new William R. Wiley Environmental Molecular Sciences Laboratory (EMSL) at Pacific Northwest National Laboratory in Washington state. EMSL, whose operational startup in 1997 corresponded with the 50th anniversary of the BER program, is the only national collaborative user facility dedicated to DOE's environmental mission (see p. 34). Research at EMSL will open new vistas on the chemistry of our environment, furnishing insights into how chemical waste streams and contaminated environments can be cleaned up and providing clues to the long-term fate of chemicals released into the ground, air, and surface waters.

# BER Accomplishments

## *Airborne Pollutant Dispersion*

- BER research helped to establish the world's earliest and most authoritative monitoring network to detect airborne radioisotopes. The use of atmospheric tracers has led to the improved ability to predict pollutant dispersion.

## *Radioecology*

BER work with radioactive tracers, together with the program's introduction of computer simulations, led to the creation of the new fields of radioecology and systems ecology.

- Specific methodologies have been developed to estimate the bioaccumulation of radionuclides in terrestrial and aquatic organisms, and the first analog models were introduced to simulate the distribution, cycling, and fate of radionuclides in ecosystems.
- The first ecology research program devoted entirely to developing a theoretical basis for understanding and predicting the behavior of complex ecology systems was initiated.
- Radionuclides were used to quantify the historical effects of human activities on aquatic environmental quality.

## *Global Climate Change*

- Improvements in cloud and radiative parameterizations and in computational techniques are leading to improvements that will be necessary for general circulation models to represent a climate system at regional and local scales.
- BER scientists quantified the ocean carbon cycle and determined the fate of carbon dioxide produced by fossil fuel combustion.
- Global carbon cycle models predicted the future doubling of atmospheric carbon dioxide from the combustion of fossil fuels.
- Global change research produced a historical climate database revealing a global trend of rising night-time temperatures over the past 50 years, a finding consistent with the greenhouse gas warming theory.

## *Bioremediation*

- After receiving EPA approval, BER scientists initiated the first U.S. field trial of a genetically engineered microorganism used to monitor biodegradation of polycyclic aromatic hydrocarbons, a first step toward developing a process for degrading these chemicals in contaminated soils.

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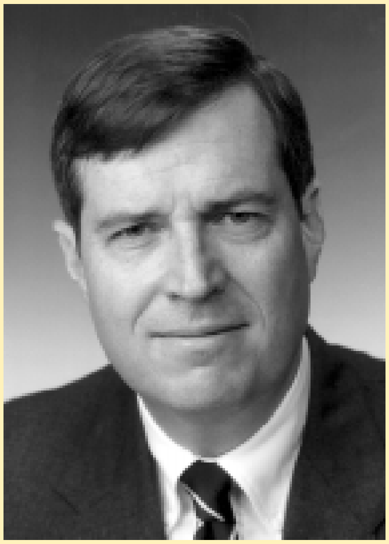
# *James Edmonds*



**James Edmonds, Ph.D.**
**Pacific Northwest National Laboratory**
**Washington, D.C.**

James A. Edmonds is a Chief Scientist and Technical Leader of Economic Programs at the Washington, D.C., office of Pacific Northwest National Laboratory (PNNL). He has been associated with PNNL since 1986, during which time he has fostered programs in global climate change and sustainable development. Codeveloper of the well-known Edmonds-Reilly-Barns model of global energy and economy, Dr. Edmonds has written several books and numerous papers on global change. He serves on a variety of advisory committees, testifies before the U.S. Congress on related issues, and provides briefings to DOE and other Executive Branch organizations on issues related to climate change. He also acts as a reviewer and editor for numerous journals.

Dr. Edmonds' current focus is on policy research and on developing the Global Change Assessment Model system. His Global Climate Change Group received the PNNL Director's Award for Research Excellence in 1995.

Before joining PNNL, Dr. Edmonds headed the Washington, D.C., office of the Institute for Energy Analysis, Oak Ridge Associated Universities (1978–86). He previously served as an assistant professor of economics and Chairman of the Department of Economics and Business Administration at Centre College of Kentucky (1974–78). Dr. Edmonds received an M.A. and a Ph.D. from Duke University.

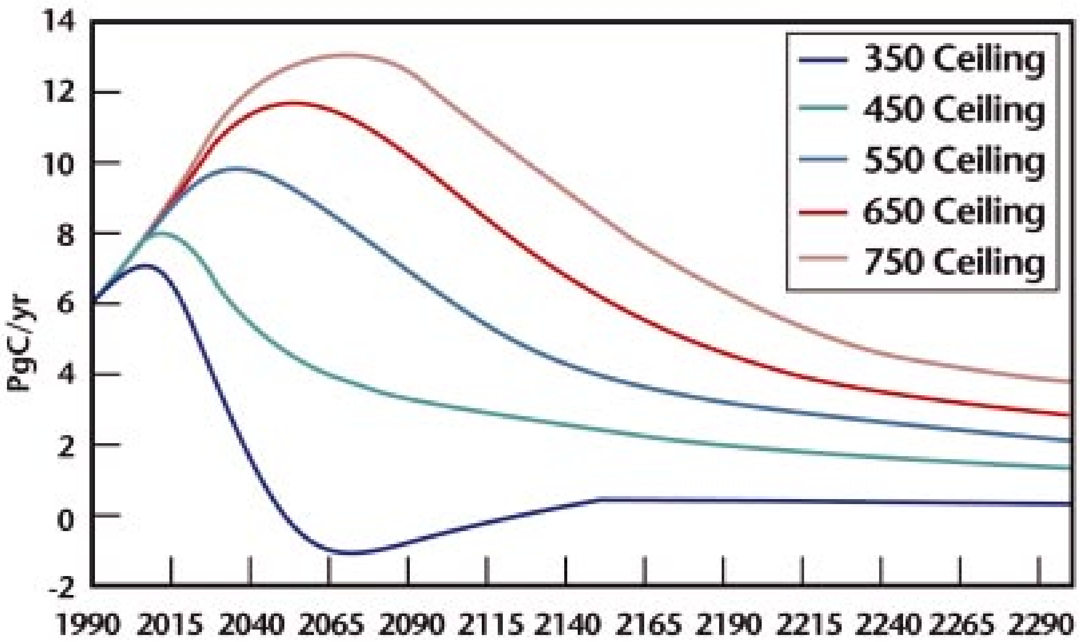
*"In recognition of your . . . research . . . to understand the environmental and economic consequences of carbon dioxide emissions and for developing innovative models to assess the energy impact on climate."*

## Energy Use and Climate Change

James Edmonds has spent the last two decades working on the problem of climate change. During that time, he has watched the research move from a backwater niche of marginal academic interest, populated by a small, tight-knit community of dedicated researchers, to the center of international negotiations. At the end of 1997, these negotiations culminated in COP3 in Kyoto, with literally trillions of dollars riding on the wisdom of decisions.

When he began his work on the relationship between energy and climate in 1978, only the stewards of the Biological and Environmental Research (BER) program took the issue seriously. In supporting scientific research to illuminate the nature and structure of the issue, Dr. Edmonds points out, BER was a leader in an otherwise disinterested world. He says that after 1988, everyone was an instant expert, and it was amazing how many people suddenly realized that they had been working on climate research all their lives but just had not known it.

Dr. Edmonds' own work, which is focused on integrating knowledge about climate changes, led him to a broader appreciation of the roles of BER and the




*Profiles of Global Anthropogenic Carbon Emissions for Alternative Atmospheric Concentration Ceilings. These profiles modify previously suggested paths of carbon emissions, which were constructed prior to the development of Dr. Edmonds' Global Change Assessment Model and were less economical.*

| Steady-State Concentration → | 450 ppmv | 550 ppmv | 650 ppmv | 750 ppmv |
|---|---|---|---|---|
| Deflection Date BAU (Tech+)[a] | 2007 | 2013 | 2018 | 2023 |
| Maximum Emission Date | 2011 | 2033 | 2049 | 2062 |
| Maximum Emission[b] | 8.0 | 9.7 | 11.4 | 12.5 |

[a] The deflection date is the year in which emissions in the emissions stabilization trajectory first fell below BAU emissions by more than 0.1 PgC/yr.

[b] PgC/yr fossil fuel carbon emissions on the date of maximum total anthropogenic carbon emissions.

Office of Energy Research in laying down scientific foundations for understanding and solving the problem of climate change. Meeting the goal of the framework convention on climate change requires that the free venting of carbon from fossil fuels ultimately be replaced with noncarbon-emitting energy technologies. This change will require not only better versions of existing technologies but a whole new generation of energy technologies that currently do not exist and never will exist unless the frontiers of relevant science are pushed forward.

Developing these scientific foundations for future environmentally friendly energy systems is not a task for fair-weather researchers or for agencies without resolve, Dr. Edmonds says. The work is, in fact, a daunting challenge, but it is precisely this kind of challenge upon which BER thrives. He expects that at the time of BER 100, the program's contributions will include helping to solve the climate problem.

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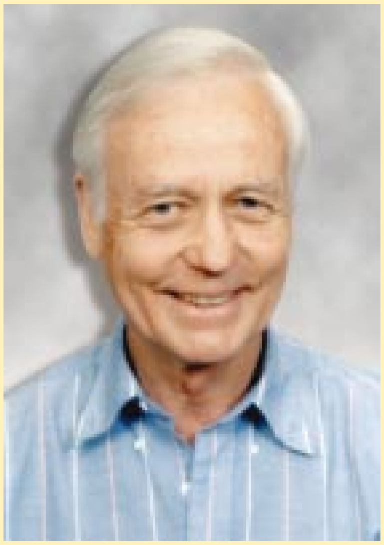
# W. Lawrence Gates



**W. Lawrence Gates, Sc.D.**
**Lawrence Livermore National Laboratory**
**Livermore, California**

W. Lawrence Gates joined the Biological and Environmental Research family in 1989 when he accepted a position at Lawrence Livermore National Laboratory to direct the newly authorized Program for Climate Model Diagnosis and Intercomparison. Before that, he was professor and Chairman of the Department of Atmospheric Sciences and Director of the Climatic Research Institute at Oregon State University. After receiving a doctorate in meteorology from the Massachusetts Institute of Technology, Dr. Gates was a research meteorologist at the Air Force Cambridge Research Center, Boston, and at the Rand Corporation in Santa Monica. He also was on the faculty of the Department of Atmospheric Sciences at the University of California at Los Angeles.

Among the professional committees on which Dr. Gates currently serves, perhaps the most important is his chairmanship of the Joint Scientific Committee for the United Nations World Climate Research Programme. He also is the founding executive editor of the international journal *Climate Dynamics*, published by Springer.

Dr. Gates' research interests range over the atmospheric and oceanic sciences, including dynamical, modeling, and diagnostic studies. In recent years, his primary interest has been climate research, with a focus on analysis, validation, and intercomparison of atmospheric and atmosphere-ocean model performance.

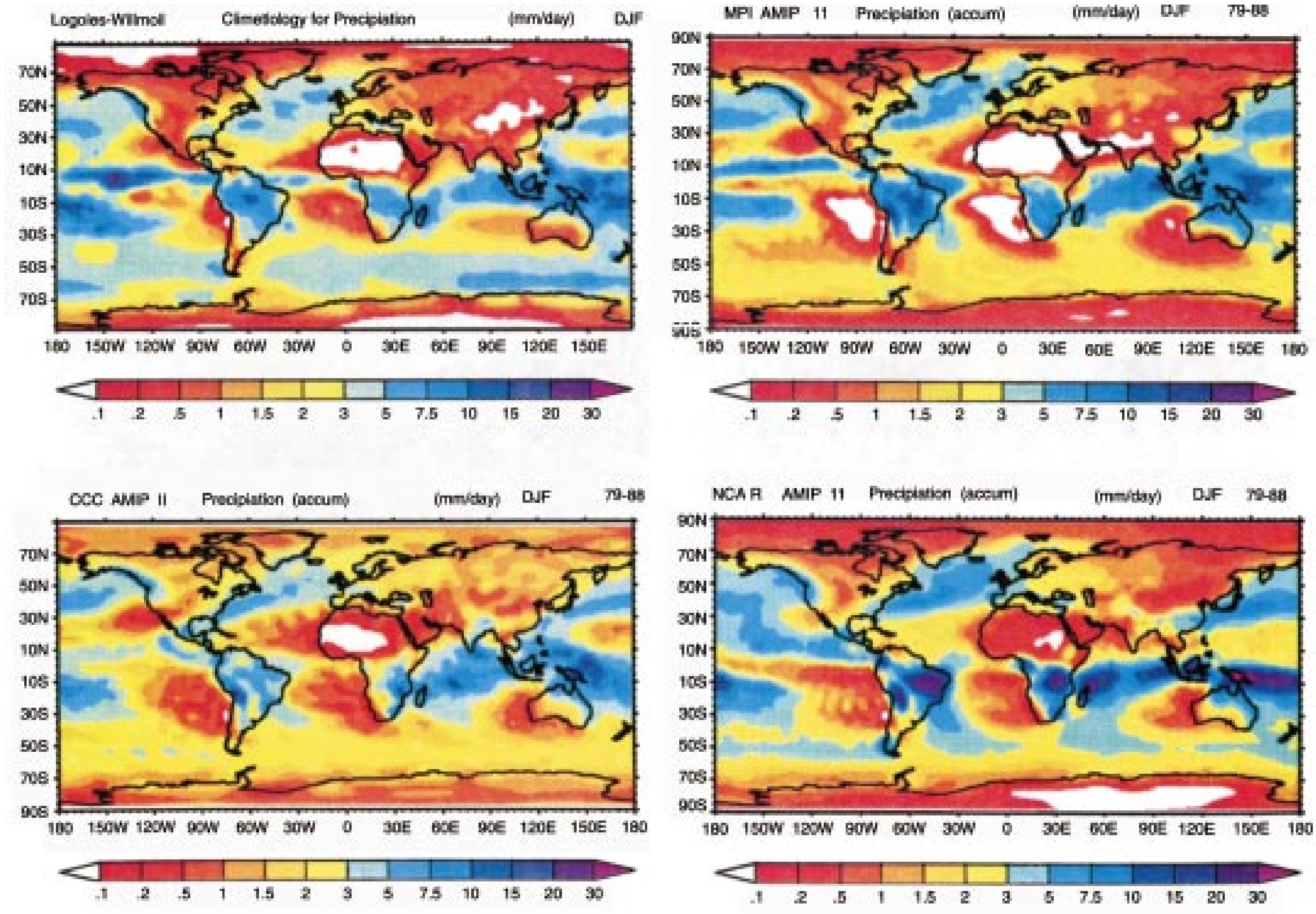
*"In recognition of your . . . research conducted in . . . global climate change through the development of methodology to intercompare climate models to systematically ascertain and correct model biases and errors."*

## Global Climate Projection

With the establishment of the Program for Climate Model Diagnosis and Intercomparison (PCMDI) at Lawrence Livermore National Laboratory in 1989, the Biological and Environmental Research Program recognized the critical need for increased climate-model accountability. Unlike weather, whose course can be predicted over a few days, projection of climate and its changes requires an accounting of long-term global interactions among atmosphere, oceans, ice, and land surface in response to often-subtle changes in the driving forces.

Climate projection can be accomplished only with mathematical and physical models whose solutions require the most powerful computers. Critical to the model's effectiveness is its ability to portray geographical and seasonal distribution of such principal climate parameters as cloudiness, precipitation, temperature, and circulation and to simulate such important phenomena as El Niño and monsoons.

In many cases, a model's errors in simulating climate changes are considerably greater than the anticipated future climate changes. In cooperating with




*Atmospheric Models for Global Climate Simulation. The observed global precipitation distribution is shown in the upper left, and simulations by three representative models are given in the other panels (Max-Planck-Institute for Meteorology, Hamburg, Germany, upper right; Canadian Climate Centre, Victoria, Canada, lower left; National Center for Atmospheric Research, Boulder, Colorado, lower right). Although all models were supplied the same information on sea-surface temperature, solar radiation, and atmospheric composition, there are apparent and different errors in each model's ability to reproduce the observed precipitation in many regions of the world. The systematic diagnosis of such errors can lead to identification of their causes and thence to improvement of the models.*

the national and international climate-modeling community, PCMDI has pioneered the systematic diagnosis of model errors and is implementing the international Atmospheric Model Intercomparison Project on behalf of the World Climate Research Programme. PCMDI also has developed widely used standards and software for data storage, display, and transmission as part of an international climate-modeling infrastructure. This work has led to the identification of heretofore-unsuspected model errors and to a new understanding of the predictability of atmospheric behavior and related climate anomalies.

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# *Michael Huston*

**Michael Huston, Ph.D.**
**Oak Ridge National Laboratory**
**Oak Ridge, Tennessee**

Michael A. Huston attended Deep Springs College in California and received a B.A. in biology from Grinnell College in 1973 and a Ph.D. in biological science from the University of Michigan in 1982. He completed a dissertation on the effects of light and nutrients on tropical rain forest succession in Costa Rica. He joined Oak Ridge National Laboratory (ORNL) in 1983 as a Wigner fellow, with research interests in ecology, forest succession, population dynamics, nutrient cycling, disturbance effects, and species diversity.

From 1987 to 1993, Dr. Huston was Project Leader of the Walker Branch Watershed Project at the ORNL National Environmental Research Park. Now a Senior Scientist in the Environmental Sciences Division, he is the author of numerous papers and a 1994 book on biological diversity. Dr. Huston served as panel member and writing coordinator of the White House Task Force for Environmental Research and Monitoring in 1995 and as a consultant for the United Nations Commission for Sustainable Development from 1994 to 1995.

*"In recognition of your . . . research . . . in developing innovative concepts of the general patterns of biodiversity and how environmental changes and human influences affect biodiversity."*

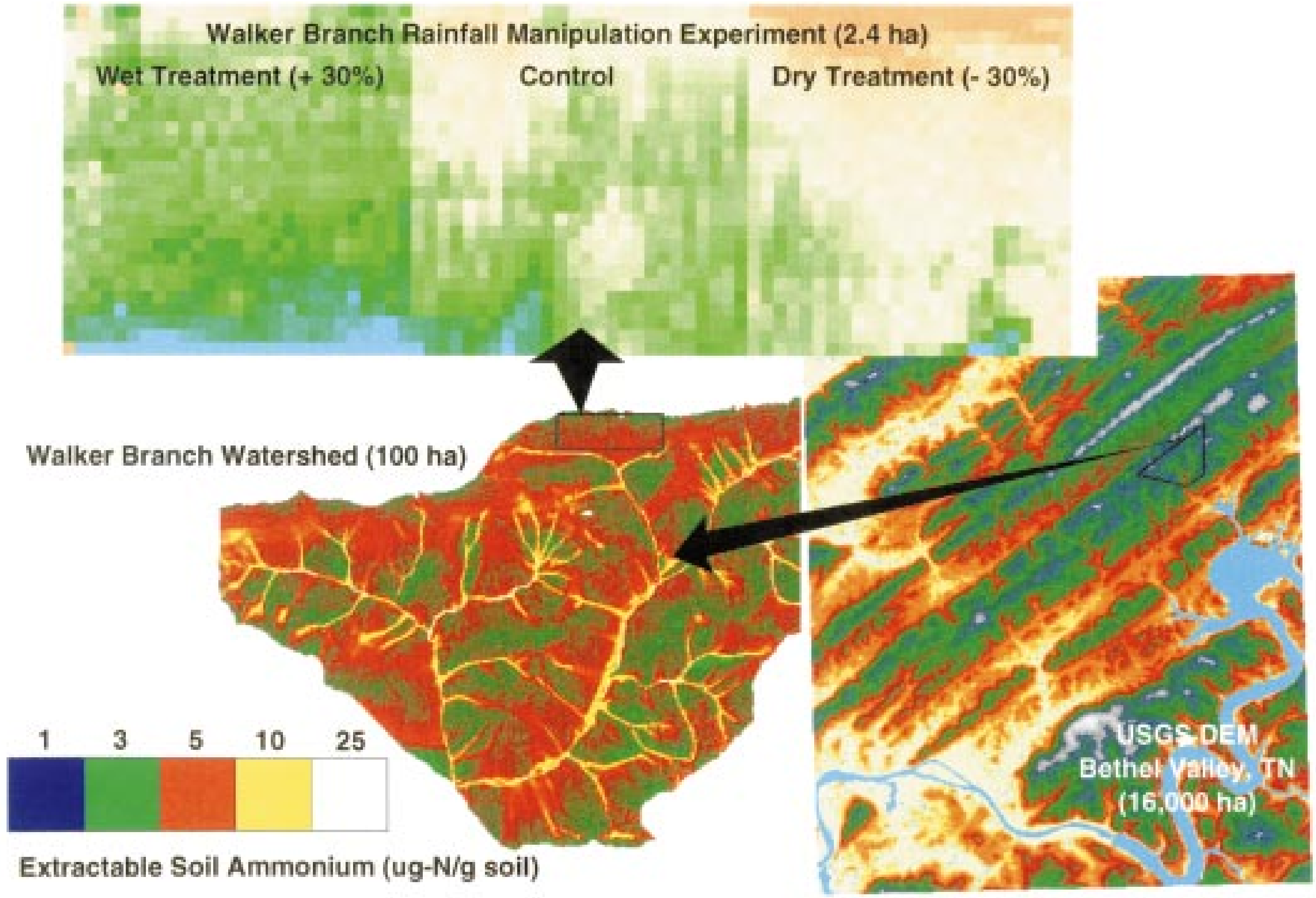
## Ecological Science

Michael Huston states that ecology is a field that sits at the interface of many sciences. Genetics, molecular biology, and cellular biology define organisms, and ecology is the study of organisms and their interactions with the environment. Scientists attempt to understand ecology through global climate modeling and a variety of studies, many of which are sponsored by DOE.

At this interface, he says, are many complex interactions directly involving humans. Humans share genetic traits with a large proportion of other organisms on earth, just as they also share the physical space of the planet itself. So ecology is a field that intimately involves people, organisms, and the environment.

"We have heard a lot about multidisciplinary fields. Ecology is perhaps the epitome of a multidisciplinary field, having to depend upon genetics and molecular biology on the one hand and on global climate and earth system studies on the other and making use of computational biology, physiology, and animal behavior. For investigators to be effective, their work must occur in a multidisciplinary context."

Dr. Huston compliments DOE's foresight in creating and perpetuating an environment in which scientists can interact with people outside their field—hydrologists, geochemists, stable isotope geochemists, physiologists, and climate modelers. Without this kind of support, he says, they could not do the kind of work they do.




*Landscape Hydrology Modeling. Computer models of landscape topography can be used to predict the consequences of interacting hydrological, ecological, and biogeochemical processes. The digital elevation model of Bethel Valley, Tennessee, shows a portion of the Oak Ridge National Environmental Research Park, bounded by the meandering Clinch River. DOE's Walker Branch Watershed research site is located on one of the long parallel ridges within this region. The colored pattern of the inset map was produced using a computer model of landscape hydrology in combination with field measurement of soil ammonium, the major form of nitrogen available to plants in most soils. The highest levels of soil ammonium are found in valley bottom areas, where favorable soil moisture conditions support tree species with leaves that decompose rapidly and release ammonium into the soil. The inset rectangular portion of Walker Branch Watershed shows a large-scale (80 by 240 meters) experiment, initiated in 1993, on the response of deciduous forests to climate change. The natural patterns of soil moisture are altered by capturing a portion of the rain falling on the "dry plot" and transferring it to the "wet plot."*

DOE had the foresight to create such unique resources as the physics facilities at Oak Ridge National Laboratory and also has established, protected, and endowed the National Environmental Research Parks on DOE's own reservation lands. Within the Environmental Research Park at Oak Ridge, the Walker Branch Watershed is now entering its 30th year of continuous DOE-supported long-term intensive research on the ecosystem. This basic research addresses a suite of problems related to the impacts of energy and energy technologies on the environment. Dr. Huston points out that such field facilities and computers, along with the expertise of outstanding people, have made possible many significant accomplishments.

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# *Michael Knotek*

*"In recognition of your . . . leadership in bringing to fruition the William R. Wiley Environmental Molecular Sciences Laboratory, a national collaborative user facility for providing innovative approaches to meet the needs of the Department's environmental missions."*

**Michael Knotek, Ph.D.**
**Argonne National Laboratory**
**Argonne, Illinois**

After earning a B.S. in physics from Iowa State University and M.S. and Ph.D. degrees in physics from the University of California, Riverside, Michael Knotek participated in the Quantum Theory Project at the University of Florida and worked on transport in organic systems at Oklahoma State University. Since the late 1970s, Dr. Knotek has been studying synchrotron radiation and the properties and phenomena of matter.

Before 1985, he was affiliated with Sandia National Laboratories and later was Chairman of the National Synchrotron Light Source, a DOE user facility on Long Island. From 1989 through 1994, Dr. Knotek served as Director of the William R. Wiley Environmental Molecular Sciences Laboratory (EMSL) at Pacific Northwest National Laboratory, where he led the establishment of EMSL and its scientific programs.

Dr. Knotek was honored by DOE's Office of Basic Energy Sciences in 1984 for his work on stimulated desorption and in 1985 for research on stress-corrosion cracking in solids. In 1987, he was elected a fellow of the American Physical Society. He received the DOE Distinguished Associate Award in 1993 for synchrotron radiation research and in 1996 for his role in restructuring the Fusion Energy Sciences Program. Author of about 100 papers, Dr. Knotek is a member of several DOE committees, as well as numerous national and international boards and advisory groups that aim to advance science and bring its benefits to society.

## Leadership in Science

In October 1997, the William R. Wiley Environmental Molecular Sciences Laboratory (EMSL), a major national scientific user facility, opened its doors at Pacific Northwest National Laboratory. The facility's mission is to develop a molecular-level understanding of the physical, chemical, and biological processes that underlie environmental remediation, waste processing and storage, human health effects, and atmospheric chemistry. Fundamental environmental molecular science conducted at the facility will provide the knowledge base needed to address DOE's challenging environmental issues.

To address the complexities and breadth of the nation's environmental problems, a new level of experimental and theoretical capability is required in the physical and life sciences. Within the Wiley EMSL, the complement of research equipment and general laboratory infrastructure designed to meet that challenge is grouped into several different facilities: High Field Magnetic Resonance Facility, High Field Mass Spectrometry Facility, Molecular Sciences Computing Facility, and several Research Environments dedicated to surface structure and chemistry. EMSL contains several one-of-


*William R. Wiley Environmental Molecular Sciences Laboratory (EMSL). Located at Pacific Northwest National Laboratory, Richland, Washington, EMSL will provide state-of-the-science experimental and computational capabilities in environmental molecular sciences to users from universities, national laboratories, and the private sector.*

*According to Dr. Knotek, the existing 750-MHz nuclear magnetic resonance spectrometer and the ultrahigh-field instrumentation currently in development will provide unparalleled sensitivity and resolution. These technologies will facilitate investigations into biomolecular structure and the dynamics of biologically and environmentally relevant molecules.*

a-kind and first-of-a-kind instruments that will support scientific advances in a variety of disciplines.

The High Field Magnetic Resonance Facility will contain instruments to support studies of the molecular structure of enzymes, proteins, and DNA as they relate to bioremediation and cellular response effects. The Molecular Sciences Computing Facility has one of the nation's fastest massively parallel computers, which expands the capability to perform ab initio calculations of molecular structure for increasingly larger single molecules and complex systems.

The Research Environments include collections of specialized instrumentation that support fundamental research in nanostructural materials, interfacial structures and compositions, reactions at interfaces, and gas-phase monitoring and detection. These and many other unique scientific capabilities at EMSL are being used to provide the scientific solutions to DOE's environmental challenges.

Dr. Knotek stated, "Building a building is just a start. Buildings are only places for people to work and for ideas to occur. In that sense, the job has just started."

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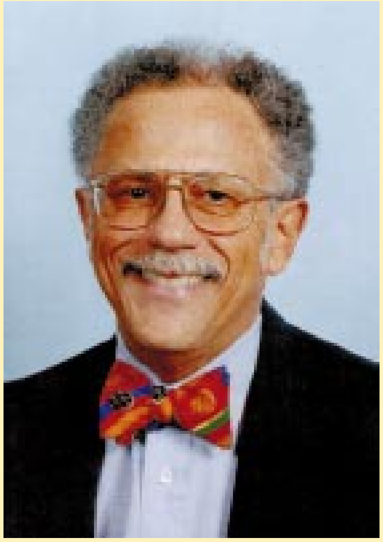
# *Warren Washington*



**Warren Washington, Ph.D.**
**National Center for Atmospheric Research**
**Boulder, Colorado**

*"In recognition of your . . . research conducted in . . . the development and application of advanced coupled atmospheric and oceanic general circulation models to study the impacts of anthropogenic activities on future climate."*

Born in Portland, Oregon, Warren Washington earned a B.S. in physics and an M.S. in meteorology from Oregon State University. After completing his Ph.D. in meteorology at Pennsylvania State University, he joined the National Center for Atmospheric Research in 1963 as a research scientist. Dr. Washington's areas of expertise are atmospheric science and climate research, and he specializes in computer modeling of the earth's climate.

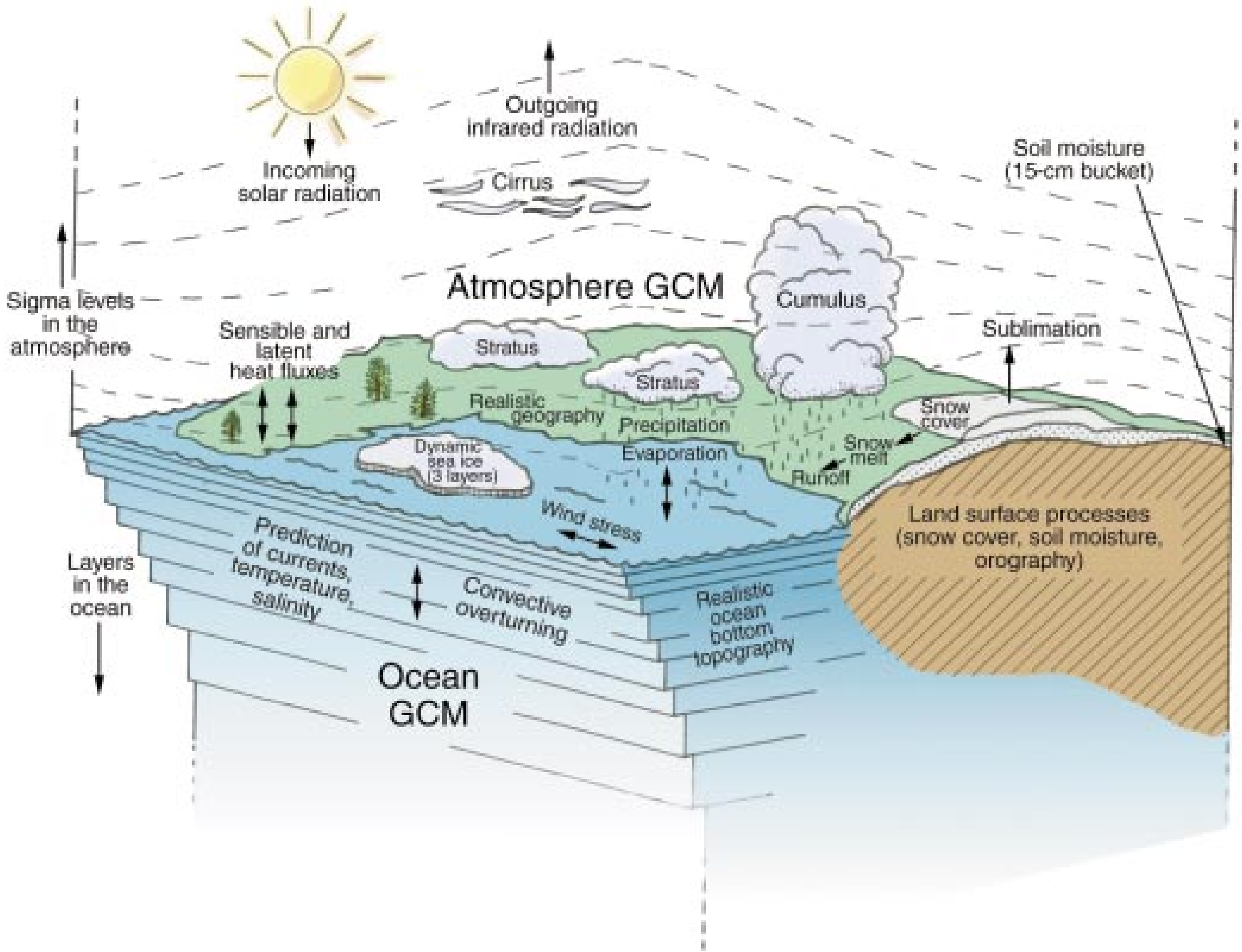
He has published more than 100 papers in professional journals and a book on climate modeling that is considered a standard reference. He has served as a climate-system modeling consultant and advisor to a number of governmental officials and committees and has been a member of numerous panels and boards. He was appointed by President Clinton to the National Science Board in 1994.

Dr. Washington is a fellow and Past President of the American Meteorological Society and a fellow of the American Association for the Advancement of Science. Among his many honors are the Le Verrier Medal of the Societé Meterologique de France, received in 1996. In February 1997, he was inducted into the National Academy of Sciences Portrait Collection of African-Americans in Science, Engineering, and Medicine.

## Climate Modeling

The DOE Biological and Environmental Research Program has been a leader in sponsoring research on possible climate change. DOE's strength in the early use of computers with an emphasis on physics contributed to the development and use of climate models.

Dr. Washington has been supported by DOE for almost 20 years in building complex three-dimensional models to study the climatic impacts of anthropogenic changes, for example, climate warming caused by the burning of fossil fuels. Over the years, the scientific community has made the model components more realistic so that, with further research and improved understanding of such processes as cloud formation and ocean circulations, current models are remarkable simulators of a climate system. Much improvement, however, is needed, and remaining shortcomings are being addressed by DOE and other governmental agencies. As the models become more certain in producing the present and past climates, they will become more reliable indicators of future climate change.




*Coupled Climate Model. This schematic shows various aspects of a coupled climate model that accounts for interactions among the atmosphere, ocean, land, and sea ice. Modern climate models predict such atmospheric variables as temperature, wind, precipitation, and cloud type; such oceanic variables as current, temperature, and salinity; and such sea ice variables as thickness, motion, and concentration. Surface temperature, snow, and soil moisture are computed over land regions. (GCM: general circulation model)*

Dr. Washington anticipates that future climate modeling will be done at not one but a number of institutions. It will be done in a distributive way, indicating that the information age is making possible cooperative research at many different sites.

"We must not pursue the quest for scientific knowledge as the only objective in our scientific research," Dr. Washington noted, "but we must also help society deal with some important issues such as climate change."