Science.

Technology.

Innovation.

# Atmospheric Science and Climate Change

Pacific Northwest National Laboratory is a leader in defining the magnitude of climate change, as well as in developing the scientific basis for practical solution strategies. PNNL takes a broad and integrated view of climate change and strives to understand its varied environmental and social dimensions. Our expertise in climate change research is providing accurate, comprehensive information for regional, national, and global models. Insights gained through our activities inform decision-makers and shape climate strategies worldwide.

## Improving Cloud and Climate Models

Clouds are a significant source of uncertainty in understanding the earth's energy budget and its impact on climate change. For more than 18 years, PNNL has been a key player in the U.S. Department of Energy's Atmospheric Radiation Measurement Program. The program's goal is to improve understanding of the interactions among clouds and of the influence of clouds on Earth's solar energy balance in order to enhance the incorporation of cloud processes into climate models.


*PNNL scientist Dr. Ruby Leung, a world-leading expert in regional climate projections, has developed regional models for the United States and China that allow for a better understanding of snow pack and other water issues.*

Through ARM and other programs, PNNL develops key regional models that contribute to development of global climate models. Comprehensive global climate modeling is difficult due to the number and complexity of physical processes involved in climate change. Scaling down from global to regional models enables researchers to draw more accurate and meaningful conclusions. Information provided by regional models is more specific and precise, and is also more relevant to local residents and their daily activities. These models help scientists understand and characterize the effects of small-scale climate features on the global climate system, and they help decision-makers understand the impacts of different environmental management options.

Management of water resources is an important issue, and there is concern about how climate change will affect water resources in the future, especially with increasing population. PNNL scientists apply basic and applied scientific disciplines to continually study and provide scientific insights into nuances of the hydrologic cycle—the circulation of water from the planet's surface to the atmosphere, and back to the surface. Our capabilities also focus on broader issues, such as water management, and atmospheric interactions, such as the integration of aerosol particles into hydrologic processes.

*To obtain the in situ measurements needed for climate studies, our researchers develop and deploy instruments and sensors in field experiments around the world.*

**Pacific Northwest National Laboratory**
Operated by Battelle for the U.S. Department of Energy


*A pilot and researcher review flight plans to prepare for an atmospheric science mission. The Gulfstream 1, operated by PNNL as a DOE research aircraft, carries sophisticated equipment for measuring atmospheric phenomena such as these particulate "clouds" over Mexico.*

## Understanding Aerosol Impacts on Climate

PNNL researchers are examining the complex effects of aerosol emissions as they impact our climate. Aerosol is a term used to describe the many types of small particles in the atmosphere. Small aerosol particles affect the natural energy balance of the Earth mainly by reflecting, and in some cases absorbing, solar radiation, and by influencing the reflective and absorbing properties of clouds. Aerosol particles can also affect atmospheric chemistry by providing sites on which chemical reactions can take place. Our scientists work with collaborators around the world to design and conduct field research to obtain data about basic aerosol chemistry and physics processes and how they affect atmospheric dynamics.

PNNL researchers are involved in a number of field campaigns to assess the aerosol-cloud interactions. For example, in June 2007 our researchers concluded a field campaign in Oklahoma using aircraft, satellite, and enhanced surface-based instrument platforms to characterize and contrast freshly emitted aerosols above, within, and below fields of cumulus humilis clouds, also known as fair-weather clouds. The resulting observations will be used to evaluate changes in atmospheric structure, increase understanding of cloud-aerosol interactions, and improve incorporation of cloud and aerosol processes into climate models.

## Collecting Accurate, Hard-to-Obtain Data

Models must be validated with observations and accurate measurements. PNNL draws on sophisticated instrumentation in the laboratory, field, and air to accomplish these tasks. In the laboratory, our researchers explore the molecular interactions occurring in the environment using advanced instrumentation, including

- Ultra-high vacuum surface and interface characterization
- High-field nuclear magnetic resonance spectroscopy
- Quadrupole Aerosol Mass Spectrometer (AMS)
- Proton Transfer Reaction Mass Spectrometer (PTRMS)
- Single Particle Laser Ablation Time-of-Flight Mass Spectrometer
- Trace Effluent Detection System
- High-performance computers and integrated software.

In the field, PNNL researchers use an array of scientific instrumentation, from traditional radar and lidar systems to the field- and air-deployable AMS and PTRMS systems, to the sophisticated instrumentation suites deployed by the ARM Climate Research Facility. As a DOE national user facility, the ARM Climate Research Facility provides the infrastructure to obtain continuous field measurements and deliver data for use by the climate change community. Our instrument development program focuses on measurement systems that can be deployed in the field, both at ground sites and onboard research aircraft, as in the Oklahoma campaign.

In the air, our scientists obtain data using manned aircraft. A key asset is PNNL's Gulfstream 1 aircraft, a large twin turboprop that can take measurements at altitudes approaching 30,000 feet over ranges of 1,500 nautical miles. The G-1 has participated in many field campaigns related to air quality, acid precipitation, aerosols, visibility, and instrument development. The aircraft is capable of speeds that enable both relatively slow sampling rates and rapid deployment to field sites throughout the world.

## About PNNL

Pacific Northwest National Laboratory, a DOE Office of Science laboratory, solves complex problems in energy, the environment, and national security. PNNL employs more than 4,000 staff and conducts a wide range of research and development projects for clients, amounting to about $750 million annually. PNNL has been managed by Ohio-based Battelle since the Lab's inception in 1965.

**Contact**
Dr. Charlette Geffen
Pacific Northwest National Laboratory
PO Box 999, MSIN: K9-34
Richland, WA 99352
509/375-3646
ca.geffen@pnl.gov

http://www.pnl.gov/atmospheric/

PNNL-SA-55482 Nov. 2007