Pacific Northwest NATIONAL LABORATORY

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PNNL scientist Dr. Ruby Leung, one of the top experts in regional climate projections, develops regional models that help decision-makers manage water and other resources.

U.S. DEPARTMENT OF ENERGY

Pacific Northwest National Laboratory

# Atmospheric Sciences and Climate Change

Through atmospheric sciences and global change research, Pacific Northwest National Laboratory is helping transform the nation's ability to predict climate change and its impacts. We're revealing unprecedented insights about how greenhouse gases are affecting our world from Chile to China and points in between. We do this by integrating the essential elements of scientific expertise, sophisticated measurement capabilities, and computer modeling at the global and regional scales. The result: a better understanding of the magnitude of climate change—and the scientific foundation for practical solutions. The science community is using our climate models regionally, nationally, and globally. Decision-makers are using our insights to shape climate and energy strategies worldwide.

## IMPROVING CLOUD AND CLIMATE MODELS

Clouds reflect sunlight and absorb heat, greatly affecting climate change. Yet cloud effects are among the largest sources of uncertainty in climate projections. The U.S. Department of Energy's Atmospheric System Research (ASR) Program, in which PNNL has played an important role for more than 18 years, is improving the understanding of cloud interactions and their influence on the earth's solar energy balance. Gradually, more realistic cloud processes are being incorporated into climate models, enabling better climate impact predictions.

Through ASR and other programs, PNNL develops regional models that stand on their own and contribute to global climate models. Comprehensive global climate modeling is difficult because of the breadth 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 various environmental management options.

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

Courtesy: U.S. Department of Energy's Atmospheric Radiation Measurement Climate Research Facility

As populations increase, people are concerned about how climate change will affect water resources. PNNL scientists apply basic and applied scientific disciplines to 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. We also focus on water management and atmospheric interactions, such as the integration of aerosol particles into hydrologic processes.

## 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. For example, in 2008 our researchers played lead roles in a month-long field campaign in Alaska. The multi-agency field study packed more than 40 analytical instruments in a research aircraft. Among the instruments was the world's most sensitive and precise spectrometer, designed by PNNL, for characterizing single particles at the nanometer scale. The results of that campaign are being used to improve the accuracy of climate models with more realistic Arctic cloud representations and resulting energy feedbacks.

## VALIDATING MODELS WITH MEASUREMENTS

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.

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.

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.

## ABOUT PNNL

Pacific Northwest National Laboratory, a DOE Office of Science laboratory, delivers science and technology to address complex problems in science, energy, the environment, and national security. With more than 4,000 staff, we conduct a wide range of research and development projects for clients, representing more than $850 million in budget outlays annually. PNNL has been managed by Ohio-based Battelle since the Laboratory's inception in 1965.

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