ARM Research Highlights

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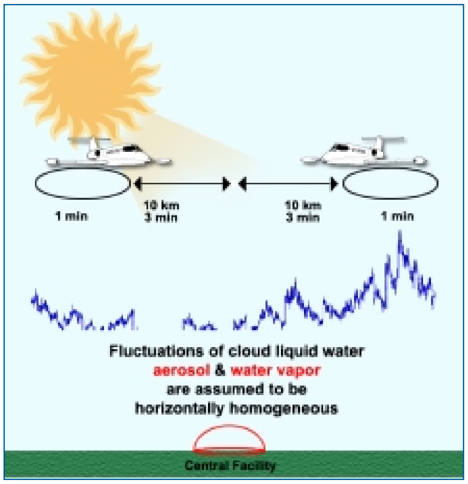
New Way of Looking at Clouds Proves Successful for Arctic Conditions

Cloud phase is an important component for correctly modeling cloud microphysical and optical properties, and thus the impact of the cloud on the solar and terrestrial radiation budget. Assuming an incorrect phase for the model can lead to errors up to 100% in particle size and optical thickness, resulting in errors of 5-20% in the amount of modeled radiation reaching the surface. The determination of cloud phase for the Arctic has been a scientific challenge, since the underlying snow-covered surface, persistent temperature inversions, and long periods of polar night make satellite retrievals very difficult. Currently there are no instruments in the Arctic for measuring the cloud phase; thus, scientists have had little information about cloud phase there. Using radiative transfer simulations, Atmospheric Radiation Monitoring (ARM) scientists developed a new method to estimate cloud phase (the amount of liquid water and/or ice in clouds) from ground-based measurements. Using the new algorithm, the investigators have created the first data set of cloud phase at the ARM site in Barrow, Alaska. These data are being used to refine climate models and parameterizations as they relate to the arctic environment, which is the most sensitive region to climate change.

The Surface Heat Budget of the Arctic (SHEBA) experiment in Barrow, Alaska, used data collected by the ground-based radiation observations from the Atmospheric Emitted Radiance Interferometer (AERI). (Photo Credit: SHEBA Project)

ARM Research Resolves Climate Model Controversy

ARM results published in the *Journal of Geophysical Research* (9 May 2003) and *Science* (20 June 2003) resolve a long-standing discrepancy between modeled and observed solar absorption. The controversy began with findings published in *Science* in 1995 that indicated that clouds absorb 40% more incoming solar energy sunlight than model calculations suggested they should. This phenomenon, called excess or anomalous absorption, is defined as the difference between measured and calculated absorption. If anomalous absorption were true, the implications were that radiative transfer models, the component of models that calculates how gases and cloud droplets absorb, scatter, and reradiate solar radiation, were flawed. In the fall of 1995, the ARM Program began its investigation of this scientific question with the Southern Great Plains (SGP) field experiment, the ARM Enhanced Shortwave Experiment (ARESE). Unfortunately, only one day of acceptable conditions provided inconclusive results. Given the lack of resolution, ARM hosted a second experiment, ARESE II,

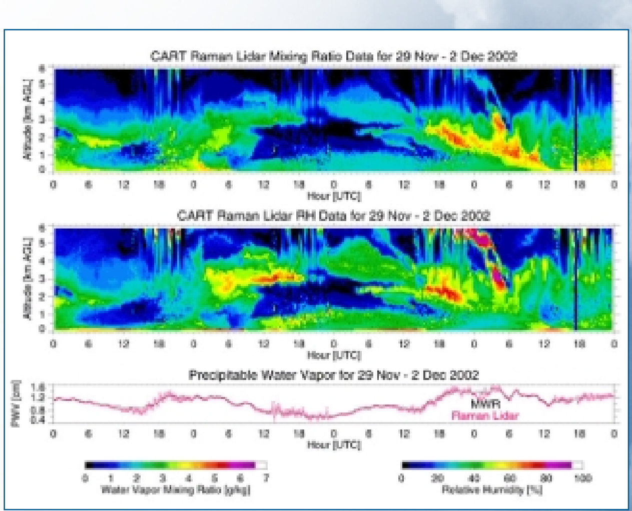


A schematic plot of the Observing System Simulation.

again at its SGP site. Between the two experiments, ARM made improvements in the radiative transfer models to treat solar absorption and scattering in a detailed, explicit manner. The effects of aerosols were also included. Comparisons between results from ARESE II and the new generation models indicate that calculated absorption is accurate to about 5% and depends most critically on the specified aerosol type. This discrepancy is now within the error of the measurements.

Progress in Understanding Water Vapor's Role in Models

After years of sustained research efforts into the accuracy of atmospheric water vapor measurements, ARM researchers have succeeded in reducing measurement uncertainties from greater than 25% to less than 3%. This improvement is critically important for understanding trends in water vapor concentrations over the past several decades, which are intimately linked to our understanding of climate change over that same period. In addition, these measurements are important constraints on the current generation of climate models, which, as they are fine-turned, will allow scientists to better predict climate change. A large part of the recent success stemmed from a series of water vapor intensive observation periods (WVIOPs) conducted at the ARM site in Oklahoma between 1996 and 2000. The goals of these WVIOPs were to characterize the accuracy of the new ARM operational water vapor observations from the microwave radiometer and Raman lidar and to use these new measurements to assess the accuracy of routine radiosonde measurements. ARM scientists have made great progress in addressing both goals.



Time-height cross sections of water vapor mixing ratio, which is observed directly by the ARM Raman lidar at 10-min and approximately 100 m resolution, and relative humidity for 29 November through 2 December 2002.

International Experiment Reduces Uncertainties Associated with Downward Longwave Irradiance Measurements

IPASRC-II instruments deployed at ARM's Barrow Station in Alaska.

Accurate measurements of longwave irradiance are important to understanding the total energy balance of the earth-ocean-atmosphere system. Arctic winter presents special challenges for measurement and modeling of downward longwave irradiance. Questions exist about the representativeness of the instrument calibration and consistency and uncertainty of measurements and models in these environments. In March 2001, the ARM Program hosted the Second International Pyrgeometer and Absolute Sky-scanning Radiometer Comparison (IPASRC-II) along with members of 11 international institutions to reduce these uncertainties. This event provided a unique opportunity to compare high-accuracy downward longwave irradiance measurements and radiative transfer model computations during conditions of extreme cold. A key result from this experiment indicates that the absolute uncertainty of measured downward longwave irradiance under arctic winter conditions is within ±2 W m^{-2}. Another key finding was the demonstrated importance of field calibrations (versus laboratory blackbody calibration) for the relevant environmental conditions.

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