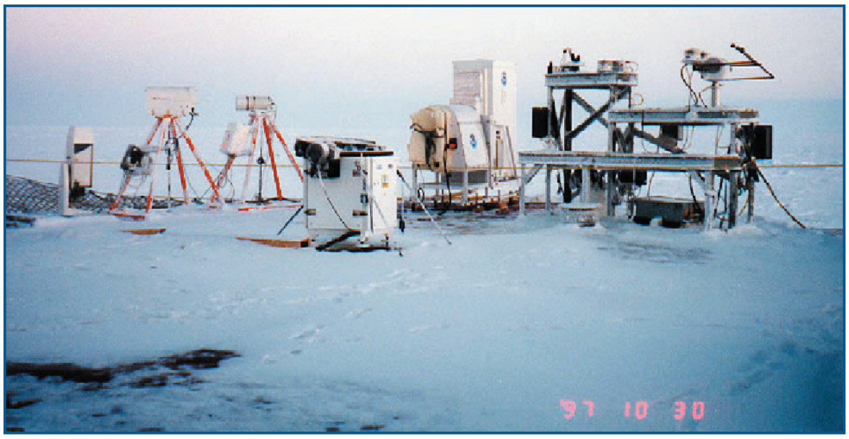
ARM Research Highlights

Going Platinum: ARM Program Contributes to Arctic Cloud CDs

In two separate CD collections, Atmospheric Radiation Measurement (ARM) Program collaborators at the National Oceanic and Atmospheric Administration (NOAA) have produced a compendium of cloud microphysical properties from research conducted in the Arctic. The two collections include (1) Cloud Microphysical Properties from Barrow, Alaska, Version 1 (August 2003), a 3-CD series that covers data retrieved in 2000, 2001, and 2002; and (2) Cloud Microphysical Properties from the Surface Heat Budget of the Arctic Ocean (SHEBA) Project, Version 2 (January 2004). ARM data sets and retrieval products from different retrieval techniques were used in both efforts.



A suite of instruments from the ARM Program and NOAA's Environmental Technology Laboratory collect arctic weather data. (photo credit: SHEBA Project)

Long-term data sets provided by instrumentation at ARM sites allow atmospheric researchers to refine specific components—such as cloud properties—used in computer models that simulate the earth's climate.

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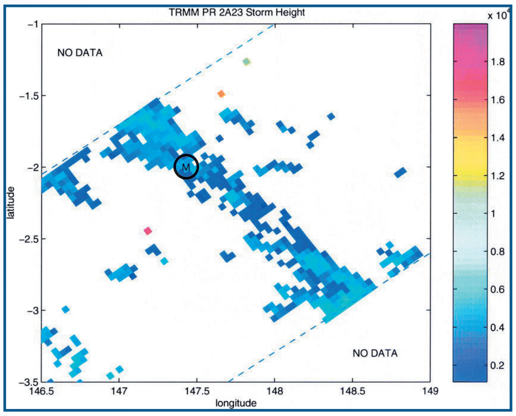
June 2004

Deep Convective Clouds and the Missing Link

The extreme environmental conditions contained in a deep-convective system (referred to as thunder clouds over land) play a significant role in the transfer of heat and energy between the earth surface and the atmosphere. These systems warm the atmosphere by the release of latent heat when water vapor condenses, and through absorption of solar and infrared radiation.

To evaluate the relative contribution of radiative versus latent heating, climate researchers used combined measurements from ground-based instruments at the ARM Program tropical sites at Manus, Papua New Guinea; and Nauru Island; and from satellite observations obtained from the Tropical Rainfall Measuring Mission (TRMM).



TRMM precipitation radar echo-top height (m) for 2225 Universal Time Coordinates February 9, 1998. The location of the Manus ARM site is indicated by the M.

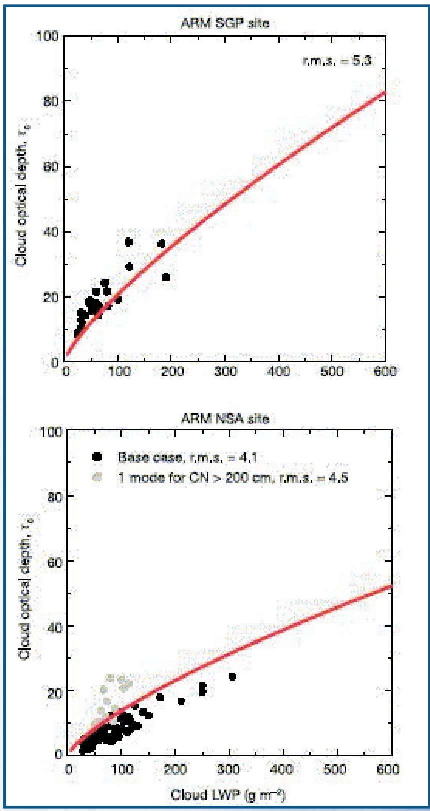
Distinctive differences were found between the radiative heating of deep convection versus midlevel convection. This led the researchers to hypothesize a link between the thermodynamics of the environment and the vertical extent and structure of convective systems. If these preliminary relationships are confirmed by further research, they may provide a useful constraint on the upper limit of tropical cloud forcing (the effect of clouds on the planetary radiation budget) used in climate models.

The Highs and Lows of Aerosol Concentration

A key variable in simulating climate is the effect of aerosols on cloud reflectivity. Most climate scientists agree that, as clouds form, the greater the initial aerosol concentration, the more cloud droplets are produced of smaller average size, all other variables being equal. Smaller droplets produce a greater optical depth, making the clouds more reflective and less transmissive of solar radiation. Proving this, however, is very difficult, because cloud formation involves a highly complex combination of variables. These variables include aerosol number and size, vertical updraft speed (which drives the amount of condensed water), and temperature and humidity profiles.

Research reported in *Nature* (15 Jan 2004) provides corroborating evidence that for low-level clouds, aerosols do affect cloud properties relative to the initial aerosol concentration. Researchers used data from low-level clouds at the ARM Program's Southern Great Plains (SGP) and North Slope of Alaska (NSA) sites to compare direct observations of high and low aerosol environments with simulations from a simple parcel model. Atmospheric conditions at the SGP site are representative of typical high aerosol concentrations, while the NSA site is representative of typical Arctic low aerosol concentrations.

By sampling a wide variety of atmospheric conditions, the ARM sites allow researchers to investigate these important aerosol effects. These results show that aerosols do impact cloud properties in significant and understandable ways. Such effects must be included in climate models to understand climate change during the current and previous centuries, because aerosol concentrations are a constantly changing part of the environment.



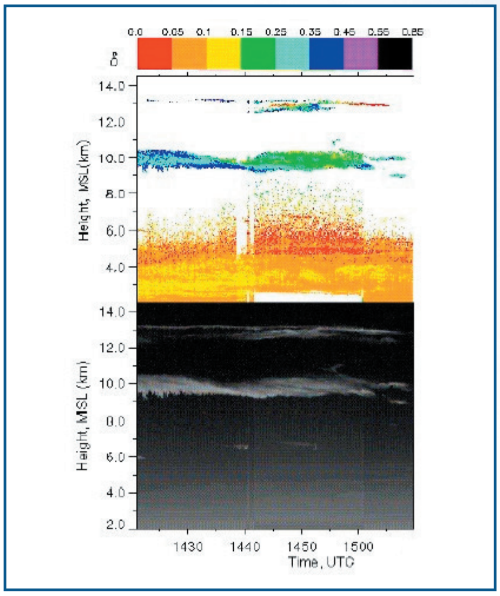
Cloud optical depth, as determined from the parcel model, is indicated by the dots. Red lines show best fit data of cloud liquid water path and optical depth determined from ARM solar and microwave radiometer measurements.

Dust in the Wind...and the Clouds...and the Atmosphere

In the northern hemisphere, major dust storms play a role in modulating climate through indirect aerosol effects. Indirect aerosol effects occur when aerosol particles modify cloud properties, thereby affecting the radiative impact of the clouds. The Mongolian and Saharan deserts are the two major source regions for dust storms capable of transporting aerosol particles long distances. In a field experiment led by the National Aeronautics and Space Administration and supported by the ARM Program, researchers used aircraft and polarization lidar to obtain data showing the potential cloud-altering properties of transported Saharan dust.

The Cirrus Regional Study of Tropical Anvils and Cirrus Layers-Florida Area Cirrus Experiment (CRYSTAL-FACE) took place in southern Florida during the time of year when Saharan dust clouds typically move from the Mid-Atlantic Ocean into the Caribbean and southern Florida.

During the experiment, the polarization diversity lidar (PDL) observed an aerosol layer extending from the top of the boundary layer to about 5.5 km. Observations indicated that the particles were non-spherical, typical of windblown dust. Simultaneous in-situ data detected a gradual increase in aerosol concentrations starting just below 4.0 km, followed by a strong increase at about 1.7 km. The in-situ evidence confirms the presence of large aerosol particles within the region in which the lidar detected supermicron-sized particles, and that these particles were unusually active with respect to ice nucleation.



PDL linear depolarization ratio (color scale on top) and relative returned power (in gray scale) of height versus time displays obtained on July 29, 2002, during the CRYSTAL-FACE experiment.

The in-situ and remote sensing data, combined with historical records, suggest an aerosol of African origin dominated by soil particles. Based on the heterogeneous ice-nucleation observed at the upper boundary of the aerosol layer, the Saharan dust particles are strongly suggestive of a cloud seeding effect from introduced ice nuclei. These secondary findings from CRYSTAL-FACE provide important data as the scientific community expands its knowledge of dust-climate interactions and their implications on climate models.

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