ARM

Cloud, Aerosol, and Complex Terrain Interactions

Clouds play a major role in the earth system. Yet, scientists do not fully understand the ways in which atmospheric conditions interact to affect storm formation, life cycle, and environmental responses. This limits the ability of numerical models to accurately represent these storms and their impacts on the earth system.

The Atmospheric Radiation Measurement (ARM) user facility, a national scientific user facility managed by the U.S. Department of Energy (DOE) Office of Science, deployed advanced atmospheric research instruments to collect data in north-central Argentina that will help improve understanding of storm environments.

ARM brought one of its three mobile facilities, along with its scanning precipitation radar and Gulfstream-159 (G-1) aircraft, to the Sierras de Córdoba mountain range west of the foothills of the Andes from October 2018 to April 2019 to conduct the **Cloud, Aerosol, and Complex Terrain Interactions (CACTI)** field campaign. This location was chosen because it is a unique hotspot for storms.

CACTI collected a large data set with an unprecedented number of storms, allowing scientists to study and isolate key processes that control storm formation, growth, and movement using this rare collection of advanced instrumentation.

ARM utilized the G-1 aircraft, operated by the ARM Aerial Facility, to gather measurements around clouds that initiate into storms.

The CACTI campaign acquired data 3,500 feet above sea level in the Sierras de Córdoba mountain range of north-central Argentina, the home of some of the tallest, largest, and most prolonged storms in the world. Photo credit: Seba Holz

Science Objectives

CACTI was designed to improve understanding of cloud growth, organization, and decay in relation to environmental conditions so that representation of these clouds and their environmental effects can be improved in earth system models.

The scientific objectives of CACTI were focused on interactions between cumulus clouds and their surrounding environment and on storm formation, growth, and organization.

CACTI data will address the following science questions:

1. How are the properties and life cycles of cumulus clouds affected by winds, thermodynamics, aerosols, and surface properties? How do cumulus clouds alter the environment around them?
2. How do winds, thermodynamics, and aerosols impact storm initiation, growth, and organization into larger, longer-lived systems? How do these storms alter the environment around them?

3. How are soil moisture, surface heat and moisture fluxes, aerosol properties, and atmospheric thermodynamics impacted by storm precipitation events and seasonal precipitation accumulation? How do these impacts feed back to cloud properties?

Research Instrumentation

Ground-based – This campaign used the ARM observatory known as the first **ARM Mobile Facility**, and operated 24 hours a day, seven days a week. Onsite technicians monitored and maintained approximately 50 instruments to ensure that the best and most complete data set was acquired.

Key instruments included a vertically-pointing Ka-band radar, a scanning dual-frequency X- and Ka-band radar, and a scanning C-band radar to measure properties of cloud and precipitation particles. The micropulse lidar monitored elevated aerosol layers and thin clouds. A Doppler lidar combined with an infrared spectral radiometer provided measurements of boundary layer winds, temperature, and humidity while radiosondes launched at two locations provided wind and thermodynamic profiles throughout the troposphere. A suite of aerosol instrumentation were used to collect measurements of aerosol optical depth, composition, size distribution, scattering, absorption; cloud condensation nuclei; ice nucleating particles; and trace gases.

Other instruments included a radar wind profiler to measure vertical wind and precipitation profiles, radiometers and eddy correlation flux measurement systems for monitoring surface fluxes, microwave radiometers for measuring precipitable water and liquid water path, and rain gauges and disdrometers for measuring rainfall characteristics. Digital cameras tracked cloud boundary location and movement.

Airborne – For CACTI, the G-1 aircraft was equipped with nearly 50 instruments for a six-week deployment beginning November 1, 2018. This instrument suite measured:

- aerosol concentration, size distribution, composition and trace gases
- aerosol optical properties, such as scattering and absorption
- energy (radiation) coming from the sun and Earth
- cloud particle (liquid/ice) mass and size distribution
- temperature, pressure, humidity, wind speed, and direction.

The ARM Mobile Facility consists of instruments, operations shelters, and data and communications systems. This portable atmospheric observatory provides flexible instrument platforms for conducting experiments lasting from six to 12 months in any global environment.

Data from the mobile and aerial observatories are freely available to scientists around the world through the ARM Data Center.

Collaborations

The DOE-funded CACTI campaign complemented and collaborated with another major field campaign called Remote sensing of Electrification, Lightning, and Meso-scale/micro-scale Processes with Adaptive Ground Observations (RELAMPAGO), in the same region of Argentina between November and December 2018. This National Science Foundation-led experiment also studied storms, but focused more on conditions that control the growth of some systems into ones that produce severe weather, such as lightning, heavy rain, hail, and high winds.

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Additional information is available on the ARM website at www.arm.gov.