ARM
Atmospheric Radiation Measurement

Fact Sheet

U.S. Department of Energy

Surface Instrumentation

Many instruments have been acquired and installed at the Southern Great Plains (SGP) field measurement site for the U.S. Department of Energy's (DOE's) Atmospheric Radiation Measurement (ARM) Program. Some instruments, such as the cloud radar and Raman lidar, have been developed with ARM support and represent the current state-of-the-art in observational capability. Together, these instruments provide a comprehensive look at the climate conditions at the 143,000-square-kilometer (55,000-square-mile) site.

Many of the same types of instruments are used at ARM field sites in the Tropical Western Pacific, the North Slope of Alaska, and in collaborative efforts at other locations.

Radiometric Observations

Radiometric observations include measurements of direct and scattered radiant energy from the sun as well as the energy emitted from the earth and the atmosphere in the form of infrared radiation.

ARM uses several types of spectral and conventional, broadband solar, and infrared radiation instruments:

- Pyranometers observe the total solar irradiance from the sky or reflected from the surface. Pyrheliometers observe the direct-beam solar irradiance.
- Pyrgeometers observe total infrared irradiance from the sky or emitted from the surface.
- Filtered, rotating shadowband radiometers detect total and diffuse solar irradiances in selected wavebands.
- Solar spectral radiometers observe total, diffuse, and direct highly spectrally resolved solar radiation reaching the ground.
- The atmospheric emitted radiance interferometer (AERI) measures infrared radiances with high accuracy and spectral resolution. The AERI is essential for experiments on the effects of greenhouse gases, clouds and fine particles on atmospheric transmission, absorption, and infrared radiation emissions.
- Spectral radiometers used to examine the spectral distribution of ultraviolet, visible, and near-infrared radiation are relatively new additions to the ARM suite of instruments.

Cloud Observations

Clouds play an important part in cooling or heating the earth's atmosphere, so some instruments observe clouds for coverage, movement, type, and size.

Sky imagers give a view of the sky as seen from the surface. They provide continuous estimates of the fraction of clouds that cover the sky, as well as measuring the height of cloud bases and dimensions of clouds. The **whole-sky imager** even provides calibrated directional sky radiances.

Sky imagers are complemented by lidars, including the **micropulse lidar**, which detects high-level cirrus clouds and maps the distribution of fine particles in the lower troposphere. While these optical devices do not penetrate clouds very deeply, they easily detect the thin cirrus clouds sometimes missed by radars. The SGP site also has a Raman lidar system that measures aerosol and cloud extention.

Observing cloud vertical extent and structure requires the use of **millimeter wavelength radar**. The ARM Program has the only continuously operating millimeter radar in the world. These zenith-pointing instruments map clouds from the ground to 20 kilometers altitudes at a resolution of 50 meters.

Aerosol Characterization

An aerosol system characterizes atmospheric particles, taking measurements at 10 meters (33 feet) above the ground to document particle size, distribution, and concentration. Lidar systems provide data on the relative distribution of aerosols in a vertical column of the atmosphere overhead.

Wind, Temperature, and Humidity Measurement Systems

Radiation processes in the atmosphere are influenced greatly by the variation of wind, temperature, and humidity as a function of height.

The **915-MHz Doppler radar wind profiler** provides information on mean wind speed in the lowest few kilometers of the atmosphere. The larger **50-MHz radar wind profiler** makes observations to greater heights but with less vertical resolution.

A **Raman lidar** is used to continuously observe vertical profiles of water vapor in the lower troposphere.

At the field sites, technicians release **radiosondes** on balloons one to eight times per day to sample vertical profiles of the wind speed, wind direction, temperature, and humidity. Typically, the balloons rise to an altitude well above 14 kilometers (8.4 miles) before they burst.

Water vapor in the atmosphere gives off very small amounts of microwave energy, which can be detected. **Microwave radiometers** that point vertically help infer the integrated amounts of water vapor and liquid in the column of sky above the instrument. They observe sky radiance at 23.8 GHz and 31.4 GHz.

Energy balance Bowen ratio or eddy correlation stations measure the rates of heat and moisture exchange between the surface of the earth and the atmosphere at selected locations. Conventional meteorological stations measure temperature, humidity, wind speed and direction, precipitation rate, snow depth, and atmospheric pressure at the surface.

Instrument and Technique Development

ARM is leading the development of new operational observational methodologies involving either new instruments or "data fusion" - i.e., using independent observed data to derive parameters either not observed or to help validate new instruments and retrievals. The ARM 35-GHz cloud radar and Raman lidar are examples of instruments developed by DOE grant-supported research. The ARM shadowband radiometers, cloud lidars, and sky imagers are examples of instruments brought by ARM from prototype or laboratory applications to field hardened, operational instruments.

To provide data not observed by any one instrument, ARM is developing value-added products (VAPs) to produce new datasets from data provided by more than one instrument. The ARM Remotely Sensed Clouds VAP, for instance, provides a cloud mask product derived from the combination of radar, lidar, and ceilometer data. The Broadband Heating Rate Profile is a VAP that exploits the thermodynamic fields derived from sonde data and the cloud property data from radar and lidar to calculate the atmospheric heating rate. These VAP datastreams are expected to expand in time and, for many intents, serve the same function as instrument-based observations.

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