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NEW CLOUD CONDENSATION NUCLEI COUNTER INSTALLED AT SGP

Accomplishing the ARM Program's objective of improving the treatment of clouds in climate models requires a detailed understanding of cloud life cycles and their radiative properties. Such an understanding is based on a good knowledge of cloud processes. New data being collected at the SGP site are helping scientists understand the processes of cloud particle formation and evolution.

Clouds form when water vapor condenses on tiny, microscopic particles (aerosols) suspended in the atmosphere. Aerosols originate from both natural and anthropogenic processes. Aerosol sources include wind-blown dust or clay, soot or black carbon from grassland or forest fires, sea salt from ocean wave spray, soot from factory smokestacks or internal combustion engines, and sulfate from volcanic activity.

For many years, the SGP site has been sampling atmospheric aerosols with the aerosol observing system (AOS). The principal AOS measurements are aerosol radiation absorption and scattering as a function of particle size and radiation wavelength. Additional AOS measurements include the particle number concentration, size distribution, hygroscopic growth, and inorganic chemical composition. These AOS measurements have helped scientists understand how aerosols interact directly with solar radiation and influence Earth's radiation budget.

Figure 1. The aerosol observing system at the SGP (ARM photo).

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Figure 2. The cloud condensation nuclei counter installed in the aerosol observing system at the SGP central facility (ARM Photo).

A deficiency of the AOS was an inability to determine, directly and automatically, which aerosols act as cloud condensation nuclei (CCN) and under what conditions this occurs. A CCN counter recently installed as part of the AOS instrument suite at the SGP site is now directly measuring CCN in the atmosphere.

The CCN counter operates by drawing air samples into a chamber held at various levels of high humidity. Aerosols that act as CCN become activated, or begin to grow into cloud droplets, when they are exposed to the high-humidity environment. The number of particles activated is counted by an optical particle counter. The SGP site's CCN counter was manufactured by Droplet Measurement Technologies; it can measure CCN size distributions (in 20 particle size bins ranging from 0.75 to 10 micrometers) and supersaturation values (humidity in excess of 100%) of 0.1% to 2%.

Aerosols influence Earth's radiation budget both directly and indirectly. The *direct aerosol effect* (mentioned above) involves direct absorption and scattering of solar radiation by the aerosols. The *indirect aerosol effect* arises from aerosols' influence on cloud properties and the implications of the resulting changes in cloud properties for Earth's radiation budget. Generating data needed to improve characterization the indirect aerosol effect is the primary task of the new CCN counter.

Cloud characteristics depend on the concentration and type of CCN in the atmosphere. An increase in CCN concentration will lead to an increase in the number of cloud droplets. For a given amount of cloud liquid water, an increase in the CCN concentration implies more but smaller droplets. This change makes a cloud more reflective to solar radiation (brighter) and is generally thought to lead to net cooling, through increased reflection of solar radiation back into space. Changes in cloud droplet concentrations can also change the precipitation mechanisms of a cloud, potentially prolonging the cloud's lifetime.

The indirect aerosol effect is probably the most uncertain among known climate forcing agents. Much of the uncertainty arises from the poor understanding and inadequate quantitation of the relationship between CCN and cloud properties. Through their role as CCN, aerosols affect cloud properties by altering the concentration of cloud droplets and thus the brightness (reflectivity) and lifetime of clouds. These indirect aerosol effects are difficult to quantify, yet characterizing them is essential for improving understanding of how clouds affect Earth's incoming and outgoing energy. The ability to model aerosol indirect forcing is a priority for the ARM Program. Addition of the SGP site's CCN counter will help ARM accomplish this objective.