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Collaborative Efforts Between ARM and ASP/Aerosol Research During the May 2003 ARM Aerosol Intensive Observational Period (IOP)

The ARM Aerosol IOP

An ARM Aerosol IOP is planned to take place at the Southern Great Plains site over a 3-4 week period centered on May 2003. This IOP is designed to enhance understanding of the effects of aerosols on the transfer of atmospheric radiation, primarily solar radiation. The IOP will examine both the direct aerosol effect, through light scattering and absorption in cloud-free air, and the indirect aerosol effect, through modification of cloud microphysical properties. The radiative forcing of climate associated with these effects is identified as a major uncertainty in climate change studies. The ARM IOP will examine the links between aerosol microphysical properties, optical properties, and radiative transfer. The intent is to conduct a variety of "closure experiments" to develop a better understanding of these links. Routine aerosol measurements made *in situ* and by remote sensing will be supplemented by an array of sensing systems on the ground and on aircraft to characterize the physical and optical properties of aerosol properties in detail. These measurements will be made in the context of standard and enhanced ARM characterization of atmospheric radiation and of the vertical profiles of temperature and humidity above the CART central facility.

This document sets out the objectives and requirements of the ASP/Aerosol Research activities during this joint study and provides justification of this activity in the context of the requirements of both the ASP/Aerosol Research and ARM programs.

Further information on the ARM aerosol IOP is available in a draft document written by the ARM Aerosol Working Group.

Synergism with ARM investigations

The capabilities of ASP/Aerosol Research applied within the context of the ARM aerosol IOP provide a rich opportunity for synergistic research. ASP/Aerosol Research investigators will focus primarily on measurement of aerosol chemical and microphysical properties. Measurement of these aerosol properties in conjunction with ARM measurements of optical properties and radiative effects of aerosols would add knowledge about the extent to which and the processes by which specific chemical and microphysical properties influence aerosol optical properties and radiative effects, permitting testing of models. Furthermore, interpretation of the results from instrumentation operated routinely by ARM will be enhanced; this is expected to help in understanding the chemistry of aerosols where only routine chemical characterization measurements are available. The extensive information generated by the ARM IOP on characterization of the vertical structure of the atmosphere and of the vertical distribution of aerosol extensive and intensive properties will aid the interpretation of chemical measurements in the context of planetary boundary layer mixing and thermodynamic processes affecting particle characteristics. The findings are expected also to lead to better design of future field experiments by ASP/Aerosol Research and to improved interpretation of results from those experiments.

Planned ASP/Aerosol Research Measurements

ASP/Aerosol Research investigators will conduct measurements both at the surface and aboard research aircraft. Planned measurements include determination of major inorganic and organic aerosol species by real-time rapid-response instruments. A special effort could be devoted to sampling semivolatile organic vapors and aerosols. Single-particle time-of-flight mass spectrometry will provide information on the size distributed composition of particles and on the extent to which particles in a given size range exhibit similar or disparate composition. Measurement of size distributions from a few nanometers to ca 1 μm and of size-dependent hygroscopic growth will allow examination of the relations between size distribution, composition, and hygroscopic growth. Measurements of ^{7}Be and $^{210}Bi/^{210}Po/^{210}Pb$ on aerosols would be taken to investigate particle age and relative contributions from air aloft.

The Role of Aerosol Composition and Microphysics Measurements in Closure Experiments

Knowledge of the aerosol optical properties such as light scattering coefficient, light absorption coefficient, and phase function is key to the treatment of local radiative transfer in cloud-free skies. ARM investigators will characterize these optical properties by a number of *in situ* measurements. In addition, measurements of solar radiation can yield values of aerosol optical depth, and active remote sensing by the micropulse lidar and Raman lidar will measure extinction due to aerosols as function of altitude. One of the objectives of the ARM investigators will be to relate the aerosol optical properties to the scattering and absorption of radiation as a function of altitude.

A key objective of the community concerned with aerosol influences on radiation is to relate the aerosol optical properties to their chemical and microphysical properties. Because index of refraction and particle morphology are functions of particle composition, simultaneous characterization of these properties is central to meeting this objective. In principle, if the size distribution, morphology, and real and imaginary components of the index of refraction are known, the optical properties can be calculated. Comparison of measured and calculated optical properties constitutes a set of closure experiments to test models of these relationships. Obtaining the requisite chemical and microphysical characterization of the aerosol requires the sophisticated instrumentation and measurement capabilities represented in ASP/Aerosol Research.

In-situ measurement of aerosol properties (at the surface or from airborne platforms) is complicated by the fact that the particles undergo loss or uptake of water as a function of relative humidity, thereby changing their size and affecting their optical properties both through the dependence of these properties on particle size and through the change in index of refraction. Also, there may be other changes such as changes in particle morphology. One of the objectives of the ARM investigators will be to map these hygroscopic properties as a function of relative humidity as necessary input to the radiation transfer calculations. In principle, the hygroscopic growth of a particle is controlled by its composition and is therefore subject to calculation using appropriate thermodynamic models. If such calculations are then applied to a size distribution, it is possible, again in principle, to estimate the dependence of optical properties on relative humidity. This approach again leads to a set of closure experiments.

The aerosol indirect forcing is based on the dependence of cloud radiative properties of cloud droplet concentration that, in turn, depends on the aerosol loading. A key component of calculating the indirect effect is knowledge of the ability of aerosol particles to serve as cloud condensation nuclei (CCN). A component of the ARM study will be measurement of CCN spectra (number concentration of aerosol particles that activate to cloud droplets as a function of applied supersaturation). The activation threshold of an aerosol particle depends on its size and composition. There may be other controlling variables such as surface wettability, which are influenced by trace amounts of soluble material on the surface of otherwise insoluble materials. Again, in principle, the CCN spectrum should be calculable from knowledge of the composition and size distribution of the aerosol, providing opportunity for additional closure experiments.

ACRONYMS

ASP	Atmospheric Science Program
ARM	Atmospheric Radiation Program
CART	Cloud And Radiation Testbed (operating entity of ARM)
CCN	Cloud Condensation Nucleus (Nuclei)
IOP	Intensive Operational Period
TAP	Tropospheric Aerosol Program