Atmospheric Radiation Measurement Aerosol Working Group

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The stated goal of the Atmospheric Radiation Measurement (ARM) program is to improve the treatment of radiation in general circulation models (GCMs). The means for doing so will be to compare model-predicted radiative fluxes with measured fluxes at four to six permanent sites. The measured fluxes will characterize the fluxes expected on the scale of a GCM grid box.

Because aerosol optical depths at solar wavelengths vary from less than 0.01 under clean oceanic conditions to about 0.5 under hazy east coast conditions, the measured fluxes will, at the very least, need to be corrected for the altered flux characteristics due to aerosols. If the anthropogenic component of aerosols is changing with time and if the anthropogenic component of aerosol optical depths is significant (as suggested in several recent papers), general circulation models must also be improved to account for these effects. Furthermore, if aerosols also affect cloud optical depths (the Twomey effect), it becomes even more important to improve the treatment of aerosols and aerosol interactions with clouds in general circulation models.

The question that faces ARM program management, however, is how best to approach these needs. What recommended set of research questions can the ARM program address, given the experimental framework of instruments and science objectives? What are the recommended approaches (experimental and modeling) for addressing these research questions?

The ARM Aerosol Working Group has been formed to address these questions. Members include Joyce Penner (Chair), Bob Leifer, Tica Novakov and Steve Schwartz.

We know that aerosols affect the local clear-sky radiation balance and are highly variable. Therefore, ARM must, at a minimum, characterize the aerosols present at ARM sites well enough to reach the stated goal of improving the treatment of radiation in GCMs. Also, since aerosols affect the local drop size distribution and thereby affect the cloudy-sky radiation balance, ARM must characterize the liquid water path and drop size distribution present at the ARM sites.

The basic parameters needed to characterize the clear-sky radiation balance in GCMs are

- aerosol column abundance
- specific scattering and absorption coefficient of aerosols (as a function of wavelength)
- asymmetry factor (as a function of wavelength)
- water vapor column (needed to separate the effects of aerosols from the effects of water).

Additional parameters that are needed for more sophisticated or more fundamental treatments of radiative effects include

- aerosol size distribution
- refractive index (as a function of size parameter)
- full scattering phase function
- aerosol shape and morphology.

The basic parameters needed to calculate the cloudy-sky radiation balance in GCMs include

- liquid water content in cloud
- liquid water path
- mean drop size or number density.

Additional parameters that are also of possible interest for the cloudy-sky radiation balance include

- drop size distribution (for a more sophisticated treatment of radiative transfer through the cloud)
- cloud condensation nucleii (CCN) spectrum or number of CCN at a typical cloud supersaturation (0.5%)

- parameters needed to characterize the dynamics of cloud formation (e.g., temperature profile, updraft velocity, water vapor profile).

The Aerosol Working Group will define the expected surface radiation flux variations in order to determine how accurately the above-named aerosol and cloud parameters must be measured. They will also explore the accuracy of different experimental methods to measure the above-named parameters. If the accuracy of the experimental approaches introduces too much uncertainty, the calculated variations in surface radiative flux (from a radiative code that uses the measured aerosol and water parameters) would be as large or larger than the expected signal in the radiative flux due to variations in the aerosol. Determining this will help the Aerosol Working Group decide which aerosol parameters should be measured.