Design of the Aerosol Sampling Manifold for the Southern Great Plains Site

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To meet the needs of the Atmospheric Radiation Measurement (ARM) program, the Environmental Measurements Laboratory (EML) has the responsibility to establish a surface aerosol measurements program at the Southern Great Plains (SGP) site, the first Cloud and Radiation Testbed site in Lamont, Oklahoma.

During 1993, instrument procurement documents were written at EML, bids were received on a series of aerosol instruments (single wavelength and multi-wavelength integrating nephelometers, an optical particle counter, a condensation particle counter, an optical absorption monitor, and an ozone monitor), and purchase orders were approved by ARM. Upon arrival of the equipment, EML tested, evaluated, and prepared it for future installation at the SGP site.

Because of agricultural activities at and near the site, the ambient aerosol will be sampled at a height of 10 m. To facilitate sampling at this height, we designed and have started constructing a special tilt-down sampling stack and manifold for aerosol characterization. The stack is designed for both long-term use and easy maintenance. A simplified drawing of the stack and associated equipment is shown in Figure 1. For illustrative purposes, the stack is shown in the sampling and tilted position. Detailed working drawings are available for contractor installation. At the top of the stack is a rain hat containing a stainless steel screen to stop birds and insects from being sucked into the stack. The tilt-down capability allows the screen to be changed safely and easily on the ground.

At the present time, EML has scheduled installation of five instruments at SGP: a single wavelength nephelometer (γ = 550 nm), an optical particle counter (OPC), a condensation particle counter (CPC), an optical absorption monitor (OAM), and an ozone monitor. The specifications for these instruments are shown in Table 1. The aerosol instruments will be connected to a specially designed manifold (Figure 2a). A blower in the aerosol trailer pulls ~1000 L min^{-1} of air through the main stainless steel stack (10 m high). The aerosol instruments receive air through a heated sampling line. The relative humidity (RH) controller uses a sensor mounted in the non-isokinetic sampling line to maintain a constant 40% RH for the instruments. A 10-µm impactor limits the size of the aerosol reaching the nephelometer, the OAM, and the CPC. The OPC, which measures the size distribution, is connected through an isokinetic probe to the sampling line before the impactor.

The ozone monitor has its own Teflon sampling line and is mounted adjacent to the aerosol sampling stack. As the tubing enters the trailer, a temperature-controlled heater gently warms the inlet air to prevent condensation during the air-conditioning season (Figure 2b).

ARM's operating protocol requires that all the observational data be placed online and sent to the main computer facility in real time. To accomplish this goal, Richard Eagan of Argonne National Laboratory is designing the data acquisition and control system for the aerosol trailer. A field data ingestor (Sun Workstation) located in the aerosol trailer will interrogate and control instrument output via RS-232 serial interface ports. In addition, the field data ingestor will sample analog signals and perform control functions. Computer software programs will be written to assess the quality of the data before they are sent to the site data system (SDS) in the control trailer.

EML currently maintains a computer file containing back trajectory (BT) analyses (performed twice daily from January 1, 1993, to the present) for the SGP site. These trajectories are used to characterize air mass types as they pass over the site. EML is continuing to calculate and store the resulting trajectory analyses for future use by the ARM science team. To improve the air mass classification, we

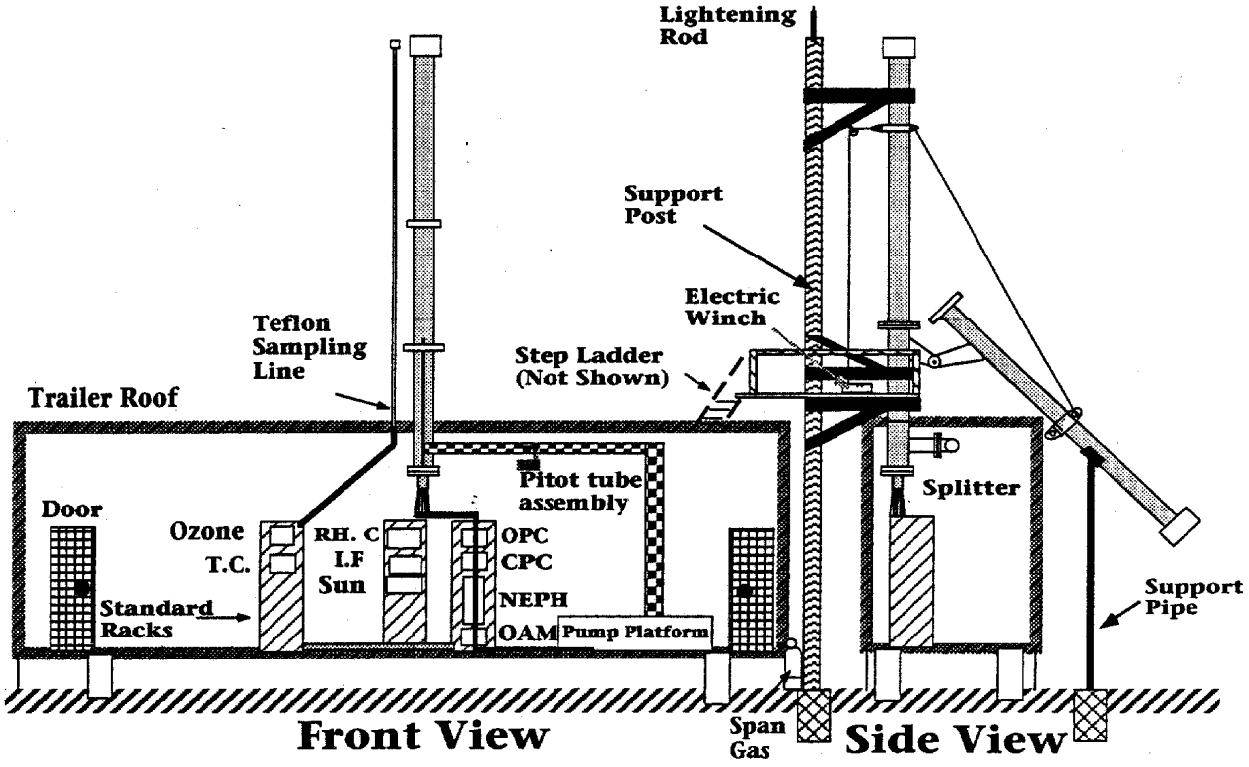

Figure 1. Aerosol sampling stack for SGP.

have included observations of the vertical temperature structure and amount of precipitation along the estimated trajectory to evaluate the modification of the upper air mass by local surface pollutants.

An example of 5 days of BT calculations (975 mb) is shown in Figure 3. The BTs are calculated backwards, every 3 h starting from the surface at Lamont. The starting date for the BT and length of time of the BT for each case are

- December 17, 1993, at 00 z (6.6 days BT)
- December 28 at 00 z (6.0 days BT)
- December 29 at 00 z (4.0 days BT)
- December 30 at 00 z (6.6 days BT)
- December 31 at 00 z (7.1 days BT).

EML plans to install a second nephelometer in one of the unused isokinetic lines (Figure 2a). This second nephelometer will provide observations referenced to a fixed "ambient" RH. The humidification system for controlling the sample air humidity will be designed and built at EML. In addition, EML has submitted to Pacific Northwest Laboratory a proposal with detailed specifications for a newly designed, commercially available multiwavelength integrating nephelometer with a backscatter detector.

Acknowledgment

The authors would like to thank the Instrumentation Division for the exceptionally fine work performed in drafting the necessary working drawings and constructing the many components of the stack and manifold.

Table 1. SGP aerosol and ozone sampling equipment specifications.

Instrument	Specifications
Integrating Nephelometer (Aerosol Scattering Coefficient) (λ=550 nm)	Radiance Research, Inc. • Detection limit: $<10^{-6}$ m^{-1} • Automatic zero and span compensated • Internal relative humidity • RS 232 output
Optical Absorption Monitor (Aerosol Absorption Coefficient) (λ=550 nm)	Radiance Research, Inc. • Detection limit: $<5X10^{-7}$ m^{-1} • Automatic zero • RS 232 output
Condensation Particle Counter	TSI, Inc., Model 3010 • Minimum detectable particle size: ~ 10 nm • Maximum detectable particle size: > 3 µm • Particle concen. from 0.0001 to 10,000 cm^{-3} • Automatic zero • RS 232 output
Optical Particle Counter	Particle Measurements Systems, Inc., Model PCASP_X_SP (NS) • 31 channels (0.1 to 10.0 µm) • 1 channel (> 10.0 µm) • Maximum count rate: 10,000 sec^{-1} • RS 232 output
Ozone Monitor	Dasibi, Model 1008 RS • Range: 0.001 to 1.000 ppm • Pressure & temperature corrected • Automatic zero and span • RS 232 output

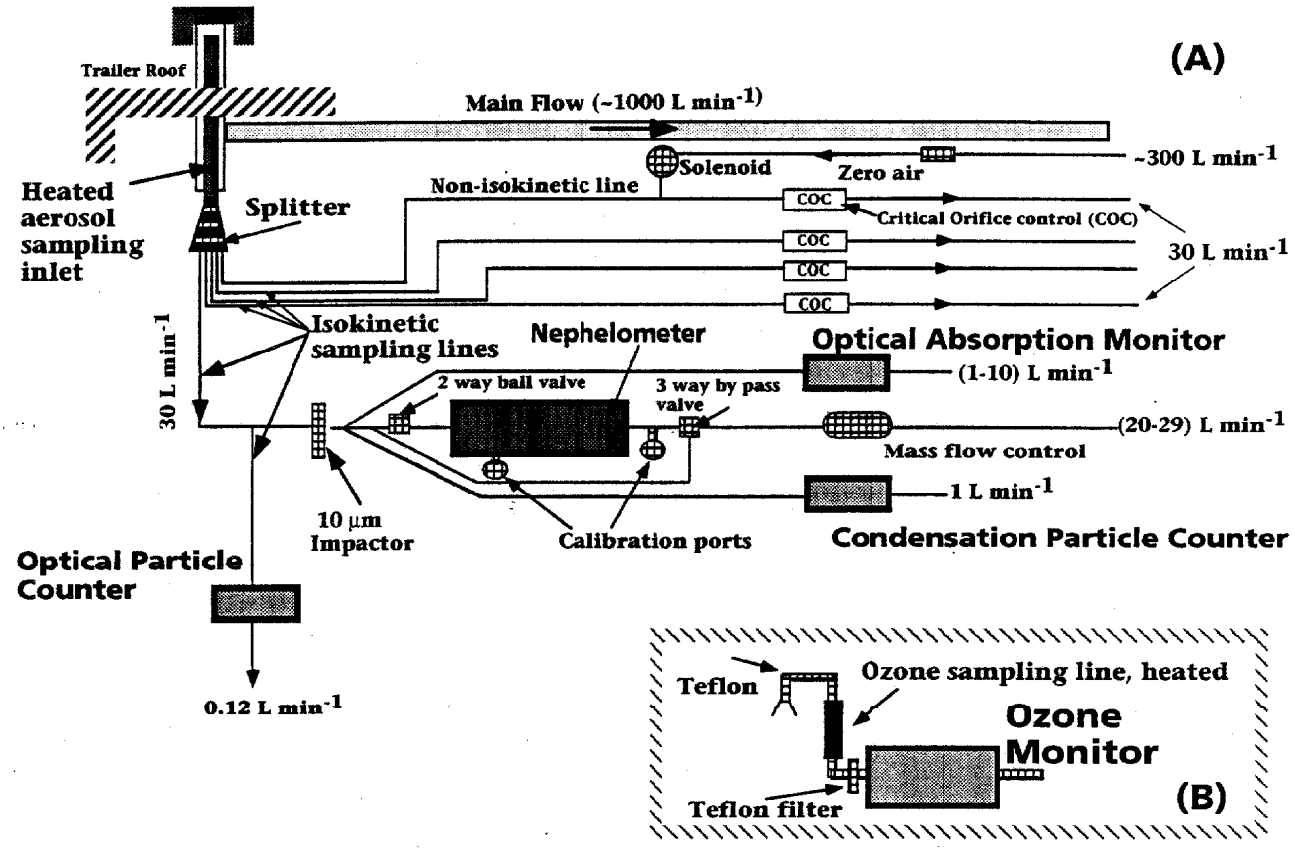

Figure 2. Sampling manifold for the aerosol equipment (a) and ozone monitor (b).

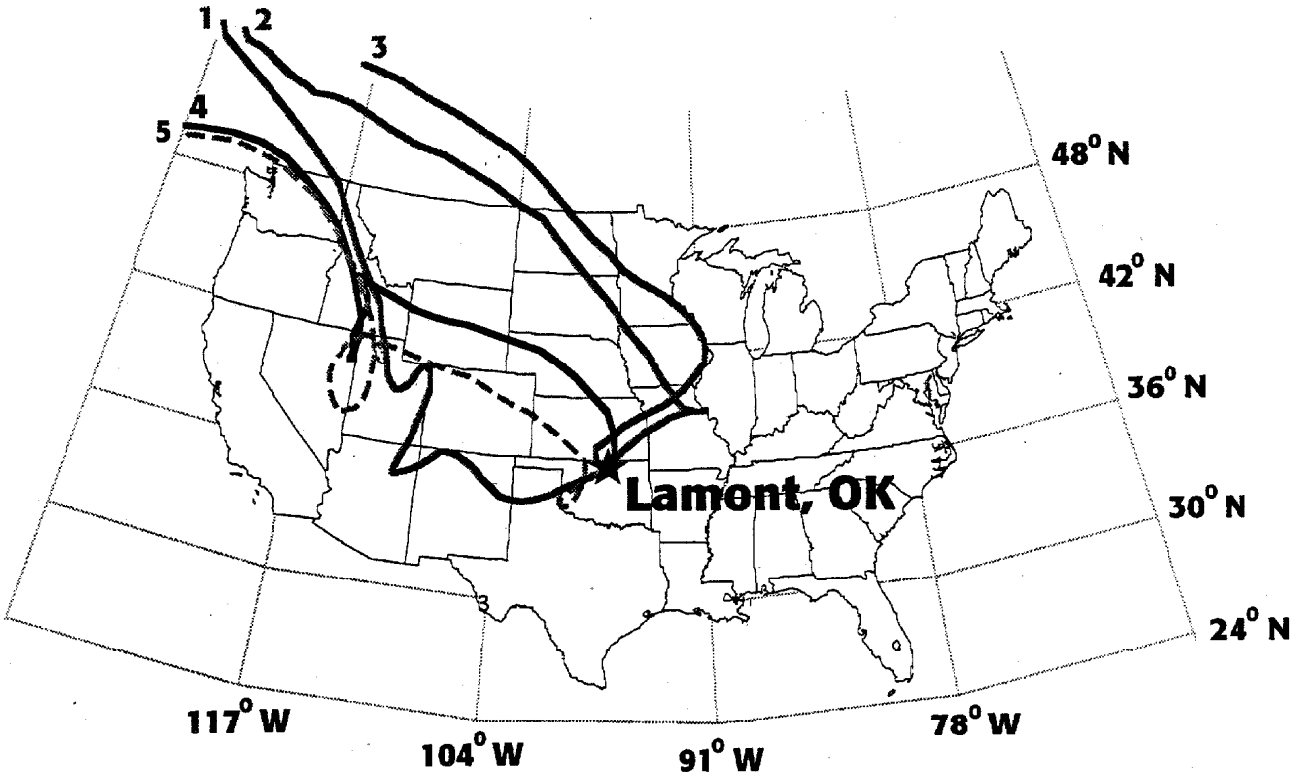

Figure 3. Back trajectory analyses (975 mb) for five cases at the SGP site in Lamont, Oklahoma.