Differential aerosol sizing and hygroscopicity spectrometer probe (DASH-SP)

Principal Investigator: Armin Sorooshian (armin@email.arizona.edu)
Department of Chemical and Environmental Engineering
Department of Atmospheric Sciences
University of Arizona

The DASH-SP will provide rapid measurements of aerosol sub-saturated hygroscopic growth factors aboard the NASA DC-8 during the SEAC^{4}RS field campaign. DASH-SP measurements in the critically important southeast Asian region will afford a valuable opportunity to examine the relationship between aerosol composition and water-uptake properties in order to improve model parameterizations of aerosol-water interactions.

The DASH-SP is described in detail by Sorooshian et al. (2008) and was developed by Brechtel Manufacturing Inc. (http://www.brechtel.com/). The instrument couples a single classification DMA system with two parallel channels consisting of controlled humidification and sizing modules (Figure 1). The modules that comprise the instrument are, in the order in which the aerosol experiences them: (1) an aerosol dryer; (2) an aerosol charge neutralizer; (3) a classification DMA that selects the dry mobility size range for which growth factor measurements are made; (4) a diffusion-based aerosol conditioning module in which the aerosol is brought to equilibrium at a controlled RH; and detectors at the outlet end that either determine (5a) the total particle concentration leaving the DMA, or (5b) the optical size distributions of the particles both after RH conditioning module and in the dry state to determine the water uptake and effective refractive index of the DMA-selected particles. The aerosol path through the instrument will now be described in greater detail.

An aerosol sample flow (~ 0.1 – 2 LPM) first passes through a Nafion dryer, and then passes through a ^{210}Po neutralizer that brings the dried particles to a stable, steady-state charge distribution. The aerosol then enters a cylindrical DMA (25 x 33 x 62 cm; 19 kg) that selects particles in a narrow interval of mobility-equivalent diameters in the 0.01 to 2.5 μm range (sheath flow rate ~ 2.5 – 10 LPM). The flow control accuracy is estimated to be +/- 3% with a precision of +/-2%. The classified aerosol leaving the DMA is split into three separate flows. In one flow, the total concentration of classified particles is determined using a butanol-based mixing condensation particle counter (mCPC, Model 1700; BMI). The mCPC serves as a redundant particle number concentration measurement against which data from the optical particle counters (OPCs) can be compared.

One of the two remaining aerosol streams is kept dry (RH < 8%), while the other is sent to a rapid diffusion-based humidification system. A key advantage of the diffusion humidifier is that no physical barrier exists between the humidifying air flow and the sample flow to be humidified. Therefore, the technique does not suffer from the large hysteresis effects seen in current, nafion-based systems and exhibits much faster time response. The humidification module is cylindrical in geometry and is supplied with a laminar, controlled-RH, filtered sheath airflow. The particle sample flow will be introduced into the humidifying cylinder so that it does not mix with the sheath flow but so diffusion of water vapor quickly adjusts the sample flow RH to near that of the sheath flow. The sheath flow RH will be controlled by mixing known volumes of dry and water saturated airflows. By carefully controlling the temperatures of the sheath and sample airflows, the precise RH performance of the unit can be maintained. The target RH operating range is estimated to be between 5% and 92%.

After RH-conditioning, the aerosol flow passes directly to custom-built OPCs, designed to detect particles in the 100 nm to 3 μm diameter size range. To ensure that particles pass through the view volume of the collection optics, the aerosol particles and a coaxial sheath are focused by acceleration through a nozzle. The design of the laser light sheet is such that all particles that enter the OPC optical cavity pass through the light. The dry, unconditioned aerosol flow from the DMA passes to a second OPC of the same design used on the humidified sample. The dry OPC measurement provides a measure of the effective refractive index of the monodisperse particles that is used to improve the sizing accuracy of the humidified OPC.

The DASH-SP can be operated manually or autonomously. In manual operation, the user specifies the RH for the humidification module, the size of particles to be selected by the DMA, and the number of particles to be sized by the OPCs before a new DMA size or RH is selected. The autonomous mode can step through a number of particle sizes and RHs, measuring a specified number of particles for each D_p/RH combination.

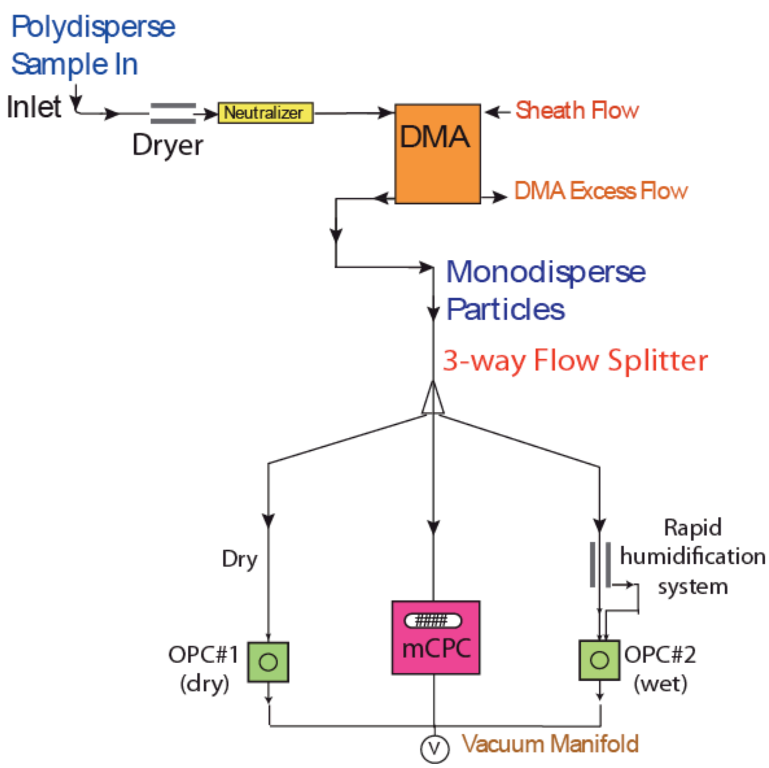

Figure 1. Schematic of the DASH-SP summarizing the transport path of sampled aerosol.

References:

Sorooshian, A., Hersey, S., Brechtel, F. J., Corless, A., Flagan, R. C., and Seinfeld, J. H. (2008). Rapid, size-resolved aerosol hygroscopic growth measurements: differential aerosol sizing and hygroscopicity spectrometer probe (DASH-SP), *Aerosol Sci. Tech.*, *42*, 445-464.