Particle Size Distribution Measurements on the NSF Gulfstream V

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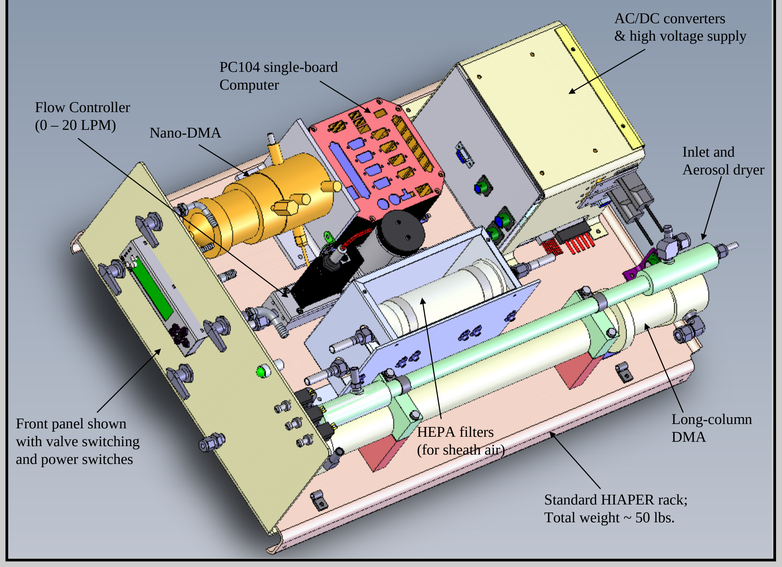
Abstract

A Scanning Mobility Particle Sizer (SMPS) has been developed for airborne measurement of atmospheric aerosol size distributions from 8 to 600 nm at the altitudes relevant to GV aircraft missions. These pressure/altitude regimes include 80kPa (~2000 m) to 15 kPa (~13000 m), the latter of which is high enough to be in the Upper Troposphere - Lower Stratosphere (UTLS) region. This ability to characterize aerosols up to the UTLS directly addresses important gaps in our knowledge of the impacts of aerosols on climate. Among the different climate forcing mechanisms documented by the Intergovernmental Panel on Climate Change (IPCC), the role that aerosols play continues to have the greatest uncertainty as indicated in the past several assessment reports.

Overview

- The GV Scanning Mobility Particle Sizer (SMPS) was developed through a collaboration between the Ultrafine Aerosols Group (NESL/ACD) and the Research Aviation Facility (EOL) at NCAR.
- The instrument can operate with a nanometer Differential Mobility Analyzer (DMA) or a long DMA, or the two can be combined to cover a size range from ~7.5 nm to >300 nm. This poster will focus on the nano DMA configuration deployed on the GV for DC3 and SEAC4RS.
- First official field deployments: DC3 (Deep Convective Clouds and Chemistry) campaign – May, June 2012. Followed by SEAC4RS campaign in Thailand.
- The DC3 and SEAC4RS science questions that are relevant to the SMPS measurements include:
  - What is the role of deep convection and lightning NOx on particle transport and new particle formation?
  - How might these processes influence climate through direct scatter/absorption or radiation, or through cloud formation and modification?

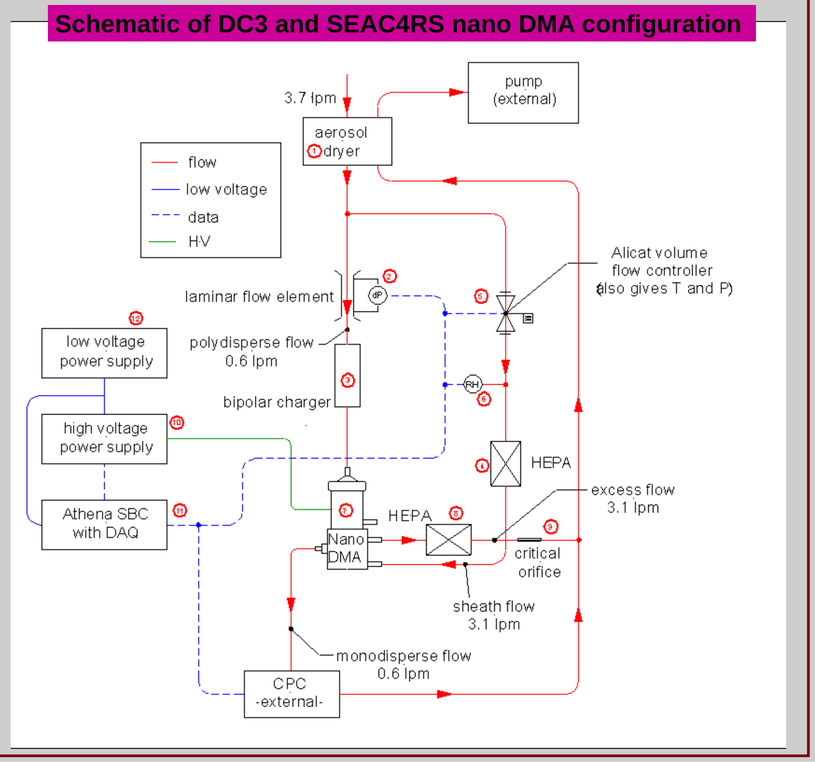
Instrument layout of expanded two-DMA configuration (condensation particle counter and external pump not shown)



Current specifications and configuration (June 2012)

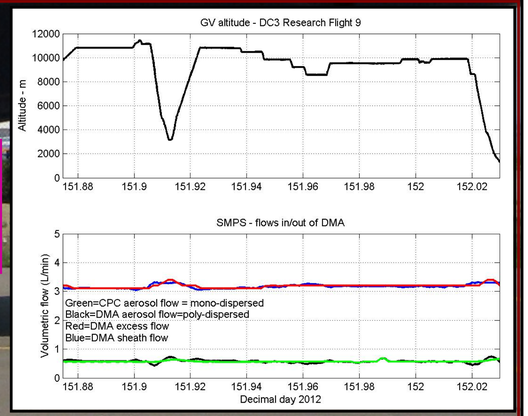
Diameter Range	7.5- 150 nm (extendable to 600 nm with long DMA).
Instrument Control	PC104 computer running Labview for instrument control and data storage. Lower Dp set by inlet pressure (~7.5 nm). Sheath/excess flows: 3.1 L/min; aerosol flows: 0.67 L/min for 5:1 ratio. Remote control and data viewing from the ground using UDP communication and satellite link.
Particle counting	TSI 3010 run at 0.67 L/min monodispersed aerosol flow. ΔT set to 25 °C; Minimum diameter (Dp min) ~ 7.5 nm.
Mobility diameter classification	TSI nano-differential mobility analyzer (DMA). Filtered sheath air provided from total inlet flow. Extendable to use with long DMA. Vmax = 3 kV
Inlet	Standard RAF HIMIL (Hiaper Modular Inlet) providing nearly unity transmission efficiency for aerosol with Dp < 100 nm.
Altitude range	1500-13,000 meters
Other instrument parameters	Sheath air temperature, flow controller pressure, sample relative humidity, pressure difference across 3 orifices (DMA aerosol flow, CPC aerosol flow, DMA excess flow) for verifying all system flows.
Scan time	60 seconds
Data product	Particle concentrations in each diameter of 15 diameter bins providing size distribution (dN/dlogDp vs. Dp) for each scan period.
Uncertainty	Diameter (±10%); Concentration(±20%);

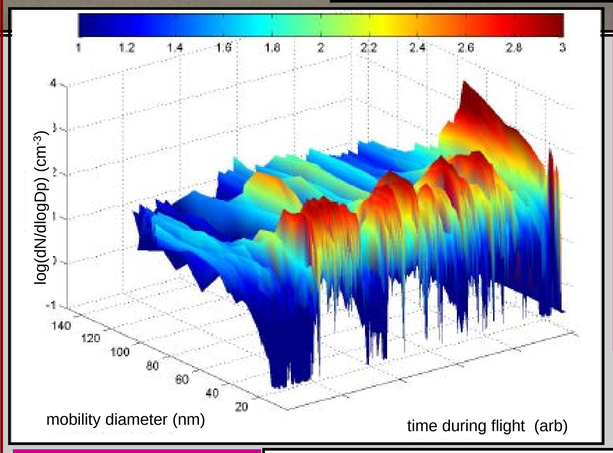
Schematic of DC3 and SEAC4RS nano DMA configuration



Case Study: DC3 Research Flight #9

The plots on the left show the stable control of sheath, excess, and aerosol flows at altitudes ranging from 2000 to > 12,000 meters





8 – 150 nm particle size distribution during DC3 Research Flight #9, showing evidence of elevated concentrations of sub-50 nm diameter particles at the highest altitudes (> 12,000 m) achieved during flight.

A plot of SMPS-derived 8 – 150 nm diameter total number concentration (top) shows that high concentrations in this size range often correlated with elevated NOx (bottom). We are currently evaluating air mass origin and other gas-phase measurements to determine the source.