AN AIRBORNE INVESTIGATION OF AEROSOL AND CLOUD PROPERTIES OVER THE ARCTIC AND BOREAL FORREST REGION

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The Langley Aerosol Research Group (LARGE) will provide fast-response measurements of aerosol and cloud properties aboard the NASA DC-8 aircraft during ARCTAS and conduct post-mission analyses to address important aerosol-related project objectives. The instrument package (see Table 1) includes measurements of: total, ultra-fine, and nonvolatile condensation nuclei (CN); the dry size distribution of 0.010 to 10 μm diameter particles; ambient size distribution of 0.6 to 20 μm diameter particles; size- and wavelength-dependent scattering and absorption coefficients; the humidity dependence of scattering (f(RH)); cloud condensation nuclei (CCN) number densities as a function of size, volatility and water vapor saturation; cloud liquid water content; and cloud particle size distributions over the 1 to 1550.0 μm size-diameter range. Archived data sets will also include calculated parameters such as aerosol surface area, volume, extinction coefficients, single scattering albedos, and angstrom exponents along with cloud ice water content, extinction, and effective particle radius. These parameters will be used to assess heterogeneous chemical effects, establish the radiative impacts of the various aerosol sources, investigate cloud-aerosol interactions, and validate satellite measurements of aerosol and cloud optical and microphysical properties.

We will also use the aircraft data along with remote sensor observations, trajectory analyses, and modeling tools to examine how biomass and anthropogenic pollution impact atmospheric composition, radiation budgets, and climate over the arctic region. Specific objectives of our studies will be to: 1) delineate the time periods when specific air masses (arctic haze, stratospheric intrusions, biomass burning, etc.) are encountered by NASA aircraft (i.e., the traditional "Air Mass Characterization Study"); 2) characterize the microphysical and optical properties of important aerosols types as functions of source region/process and air mass age; 3) examine the influence of aerosol composition, volatility and mixing state on cloud condensation potential and the droplet growth kinetics of ambient aerosols (i.e., assess potential aerosol indirect effects); and 4), use the aircraft data in combination with CALIPSO soundings and satellite AOD measurements to quantify the advective flux and lifetime of aerosol pollution over the polar region.

Figure 1. Wingtip-mounted Cloud Aerosol and Precipitation Spectrometer (CAPS, left) and the window-mounted iso-kinetic aerosol inlet (right) used to supply sample air to the LARGE instrument rack.

Table 1. LARGE Instrument Suite

Measured Parameter	*Instrument*	*Size Range (μm)*	*Response Seconds*	*Estimated Precision*
Ultrafine CN	*TSI3025*	*0.003--0.01*	*1*	*10%*
Total CN	*"Unheated" TSI3010*	*>0.01*	*1*	*5%*
Nonvolatile CN	*"Heated" TSI3010*	*>0.01*	*1*	*5%*
Dry Aerosol Size Distributions	*TSI SMPS*	*0.01 – 0.3*	*60*	*5% size, 25% conc*
	DMT UHSAS	*0.06 – 1*	*1*	*5% size, 20% conc*
	MetOne OPC	*0.3—10*	*1*	*20% size, 25% conc*
	TSI 3321	*0.5 – 20*	*1*	*10% size, 20% conc*
Dry Total Scattering at 450, 550, and 700 nm	*TSI3563 Neph*	*-*	*1*	*0.5 Mm-1*
"Dry" Total and Submicron Scattering at 530 nm	*RR Neph*	*-*	*10*	*0.5 Mm-1*
"Wet" Total and Submicron Scattering at 530 nm	*RR Neph*	*0.3 – 20*	*10*	*0.5 Mm-1*
Total and Submicron Absorption at 467, 530 and 660 nm	*RR Neph*		*10*	*0.2 Mm-1*
Cloud Particle Size Distribution	*DMT CAS + CIP*	*1– 1550*	*1*	*20% H2O, 50% ice*
Cloud Particle Images	*DMT CIP*	*50 – 1550*	*1*	*Not Applicable*
Cloud Liquid Water Content	*DMT Hot Wire*	*>3*	*1*	*0.1 g/m3or 20%*
Cloud Condensation Nuclei	*DMT CCN*	*0.02-1*	*1*	*10%*

Notes: Precision for CN counters are dependent on particle size; given values are for aerosols larger than the instrument 50% cut size (3 and 10 nm for the TSI 3025 and 3010 counters, respectively) and are primarily dependent on the precision of the instrument flow rate measurement. Size precision for the OPC, SMPS, and APS instruments were determined using latex spheres. Concentration precisions estimated by comparing measured values vs. CN counter or other particle detection systems. Nephelometer and PSAP precisions based on repeatability of standard measurements. Cloud particle measurement precision based on comparison of integrated volumes versus independent measurements of cloud water content. The CCN precision is dependent on particle size, atmospheric pressure and temperature, and instrument saturation.