

In-Situ Measurements of Single-Particle Aerosol Composition for DC3 and SEAC4RS

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The NOAA PALMS instrument (Particle Analysis by Laser Mass Spectrometry) will measure single-particle aerosol composition aboard the NASA DC-8 during the DC3 and SEAC4RS campaigns. PALMS will provide a variety of size-dependent compositional tracers to identify aerosol sources, probe mixing state, and investigate convective transport and cloud processing. PALMS has over 130 successful flights aboard the WB-57, DC-8, and NOAA P-3 aircrafts and a history of seminal publications (e.g., Murphy et al., 2006).

Aerosol particles are brought into a vacuum system via a series of aerosol focusing stages. Particles are detected by light scattered from two consecutive 532 nm laser beams where their aerodynamic diameter is measured. A scattering event triggers a vaporizing and ionizing pulse from a 193 nm excimer laser. Ions are analyzed using a time-of-flight mass spectrometer. Each detected particle produces one complete positive or negative mass spectrum. Background signal intensities from air are <0.1% of the aerosol ion signal. The PALMS size range is approximately 200-3000 nm and encompasses a large fraction of aerosol volume. Aerosol data rates are typically ~1 Hz, but data can be acquired at up to 10 Hz. PALMS maintains an effective data rate in the upper troposphere even for very low aerosol loadings, <0.01 $\mu\text{g}/\text{m}^3$.

The PALMS mass spectra allow individual aerosol particles to be classified into broad compositional categories: sulfate-organic mixtures, biomass burning, elemental carbon, mineral dust, sea salt, meteoric, industrial, and oil combustion (Fig 1). These primary data products are used to characterize aerosol sources along the aircraft flight track. PALMS size-dependent composition can be combined aerosol counting instruments to generate quantitative, composition-resolved aerosol volume (Fig 2).

A primary objective for the SEAC4RS campaign is to investigate deep convective transport of aerosol species and subsequent chemical evolution. PALMS has the unique capability to measure primary aerosol such as mineral dust, biomass burning particles, and sea salt with fast time response. Comparing the abundance of these primary particles in the lower troposphere, background upper troposphere, and cloud outflow regions will help determine the efficiency of convective redistribution. The sensitive and selective biomass burning tracer will be particularly valuable in studying the impact of Southeast Asian fires on regional upper tropospheric aerosol. In addition to the particle type classification, PALMS can resolve specific chemical species. Secondary accumulation of sulfate, nitrate, and oxidized organic material is used to determine aging and cloud processing of primary aerosol. In previous tropical campaigns, PALMS used methanesulfonic acid, particle

acidity, and organic signatures to differentiate aerosol lofted by marine versus continental convection (Froyd et al., *ACP*, 2009).

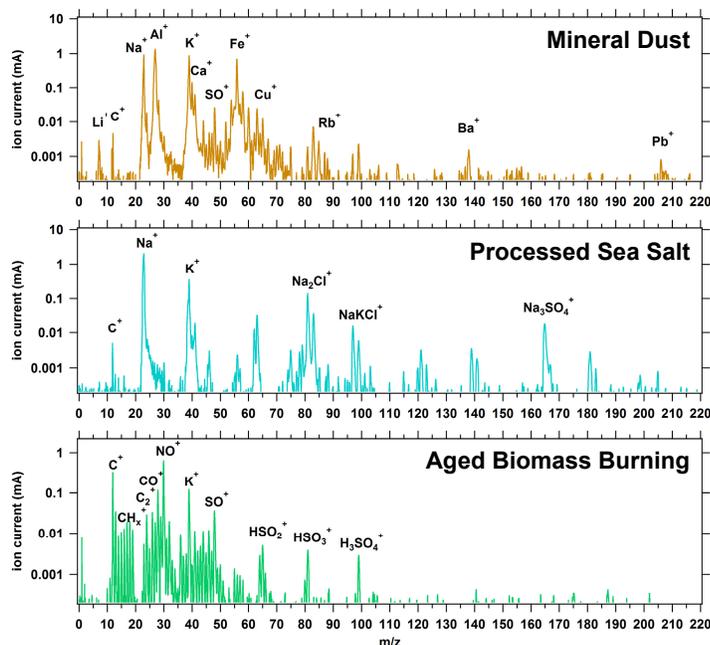


Fig 1. Single-particle mass spectra of primary aerosol.

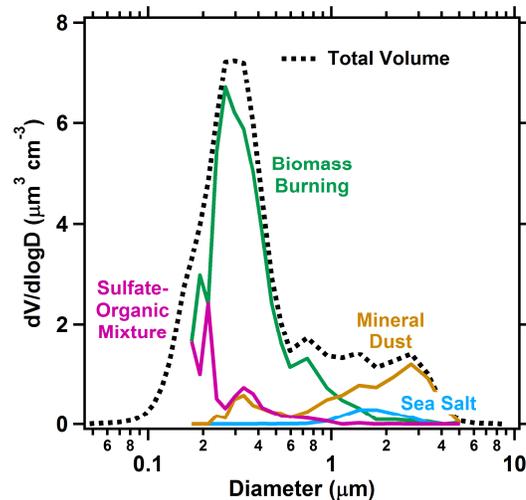


Fig 2. Quantitative volume distribution of various particle types.

PALMS recently identified and quantified an isoprene-derived organosulfate compound in free tropospheric aerosol (Froyd et al., *PNAS*, 2010). In certain regions this single compound accounted for >10% of total aerosol mass. The organosulfate is most efficiently formed by the interaction of anthropogenic pollution (SO_2) with biogenic isoprene emissions. Some Southeast Asian air masses may have extreme concentrations of these precursor species, with the potential to form significant secondary aerosol mass. PALMS will quantify the impact of this secondary mechanism on upper tropospheric aerosol.

References

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