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AIRBORNE OBSERVATIONS OF RECENT NEW PARTICLE FORMATION OVER TWO URBAN AREAS IN THE U.S.

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INTRODUCTION

Measurements of submicron particle size distributions (0.005-50 µm) were conducted on-board the U.S. Department of Energy (DOE) G-1 aircraft using a new Twin Scanning Electrical Mobility Sizer (TSEMS) and two optical particle counters. Twenty research flights were conducted during the summer of 1999 over Philadelphia, PA and 15 research flights were conducted during the summer of 2000 over Houston, TX. Measurements of photochemically active trace gasses were also made on-board the aircraft. The goals of the measurements included quantifying the differences between particle size distributions under urban-influenced and regional-background conditions, estimating particulate mass production rates within urban and power plant plumes, and examining the conditions under which recent nanoparticle (NP, D_p<15 nm) formation was observed. Evidence for recent particle formation was found only during morning flights corresponding to three distinct conditions. Firstly, NP were found aloft coincident with the interface between the developing surface boundary layer and upper residual layer. The airborne measurements of NP reported here provide some of the first *in situ* observations of the co-occurrence of NP and boundary layer inversions. Secondly, NP were found in the vicinity of chemical gradients corresponding to localized plumes of SO_2, NO_y, or O_3 within the developing boundary layer, similar to conditions reported by Birmili and Wiedensohler (2000) during ground-based measurements of NP. Finally, NP were observed in the vicinity of clouds, possibly due to conditions near cloud conducive to particle formation or due to droplet shattering in the sample inlet as reported by Weber *et al.* (1998).

METHODS

The TSEMS is a new, electrical mobility-based size distribution measurement system that has been recently developed at Brookhaven National Laboratory. It incorporates two different mobility analyzers (DMA), one TSI Model 3085 Nano-DMA and one TSI Model 3081 Long-DMA. The voltages of each DMA are simultaneously scanned so that the size distribution over the diameter range 0.005-0.8 µm is observed every 60s. TSI Model 3010 condensation particle counters (CPC) are used as particle counters for each DMA. For the NDMA, the CPC is operated so that the particle diameter detected with 50% efficiency is 7nm. Constant DMA volumetric flow rates and isokinetic flow in the main aerosol inlet are maintained independent of aircraft altitude using automatic computer control. DMA sheath flows and the polydisperse aerosol sample flow relative humidities (RH) are maintained at levels below 20%. Particle size distributions (0.1-15 µm) are measured simultaneously by two optical particle counters (OPC; PMS PCASP-100, FSSP-100) located outside the aircraft. The PCASP-100 is operated with a heater so that the sample RH is near 20%. To compare the various moments of the observed urban and regional sub-2.5 µm urban size distributions, OPC data (0.5-2.5 µm) have been merged with TSEMS data.

CONCLUSIONS

Figure 1 shows an example where high concentrations of NP were observed when the plane passed through the entrainment zone of a developing surface boundary layer. In Figure 1(a), the solid trace represents normalized NP concentration, with a maximum observed concentration of 10^5 cm^{-3}. The dotted trace designates aircraft altitude. The vertical profile of potential temperature taken during the period of high NP concentrations is shown in Figure 1(b). The start and end times of the vertical profile are each defined in Figure 1(a) by an 'x'. The arrow in Figure 1(b) shows the location of the top of the well-mixed layer near 1000 m, corresponding to the altitude in Figure 1(a) where elevated NP concentrations were observed. Plumes of photochemically active trace gasses were not observed during the high NP concentrations around 15:00 UTC, in contrast to high NP concentrations around 14:39 UTC where a distinct plume containing high concentrations of SO_2 and CO was observed. FSSP-100 concentrations were extremely low during the period.

High NP concentration events will be examined to test the hypothesis that mixing within the entrainment zone of a developing boundary layer contributes to the production of new particles.

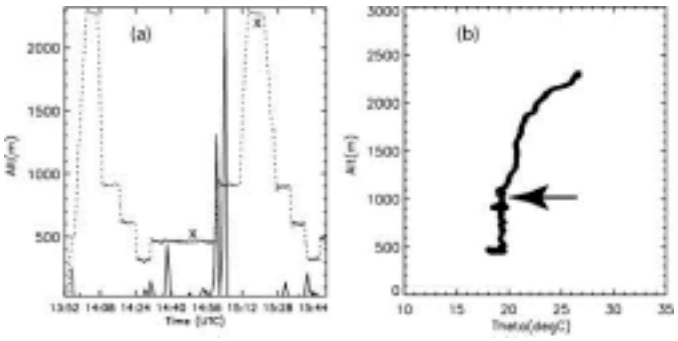

Figure 1. (a) Timelines of normalized NP concentrations (solid) and aircraft altitude (dotted) for a flight on Aug. 10, 1999. (b) Vertical sounding of potential temperature during period designated by 'x' in (a).

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