J7.3 Size Distribution and Hygroscopic Properties of Agricultural Aerosols

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INTRODUCTION

Due to significant atmospheric loadings of agricultural dust aerosols, these aerosols must be considered in assessments of the impacts of aerosols on visibility, climate forcings and human health. The hygroscopicity of atmospheric aerosols greatly affects their ability to scatter and absorb incident light (Charlson et al., 1992; Pilinis et al., 1995; Schwartz, 1996; Tang, 1996). While it is known that agricultural dust has a relatively strong affinity to water vapor (Marek et al., 2004; Razote et al., 2004), no previous studies have quantified the water taken up by dust particles as a function of relative humidity (RH). Thus, quantifying the concentration, size, and hygroscopic properties of particles emitted from cattle feedyards are crucial steps in assessing their overall impact on air quality and climate.

METHODS

A GRIMM aerosol spectrometer and Sequential Mobility Particle Sizer and Counter (SMPS) measurements were simultaneously operated at a field sampling site on the nominally downwind side of a feedlot in the Texas Panhandle. Taken together, these instruments measure size distributions of agricultural aerosols as a function of time in an overall size range of 11 nm to 20 μm diameter.

To explore the hygroscopic behavior of agricultural particles, size-resolved aerosol samples were collected at the feedlot using a cascade impactor system, and hygroscopicity measurements were conducted on these samples using an Environmental Scanning Electron Microscope (ESEM) at the on-campus Microscope and Imaging Center. The elemental compositions of the particles were also determined using an Energy Dispersive X-ray Spectroscope (EDS).

PRELIMINARY CONCLUSIONS

Figure 1. shows the volume concentration ($\mu m^3/l$) of particles in several size bins as well as the total volume of particles observed by the GRIMM spectrometer as a function of

time for three days in July 2006. As can be seen in the figure, contributions from the coarse particle size bins dominate the total volume throughout the measurement period. Dramatic diurnal cycling in total volume concentration was observed. The peaks in the evening time (~2100) coincided with an increase in cattle activity while the morning peaks (~0700) coincided with cattle feeding times. Sudden drops in volume concentration were observed directly following precipitation events on July 4^{th} and 5^{th} (scavenging of particles).

Representative ESEM images of particles collected at the feedlot are shown in Figure 2. We observed several distinct particle shapes recurring on filter samples of all sizes during microscopy analysis. Nearly all particles in all sizes imaged can be adequately described as one of three shapes, A. smooth rounded particles, B. rough-surfaced single particles with amorphous shapes, and C. agglomerations of multiple amorphous particles. Due to the consistent recurrence of particles in these shapes, we chose to conduct our hygroscopic measurements on particles in each shape group.

Figure 3. shows results of the ESEM water uptake experiments. A particle's hydroscopic growth factor (d/d_o), defined as the ratio of the humidified mobility diameter of the particles (d) to the dry mobility diameter of the particle (d_o), were observed over the range of approximately 8 – 94% RH. Our results indicate that majority of agricultural particles do not take up significant amounts of water when exposed to relative humidities (RH) up to 94%. A notable exception to this is that a fraction of the coarse mode particle population (Shape group A) deliquesced at ~75% RH and grew to twice their original dry sizes at an RH of 94%.

Ultimately, this study may improve our understanding of how the hygroscopic, chemical and morphological properties of agricultural particles influence climate and air quality at a regional to global level.

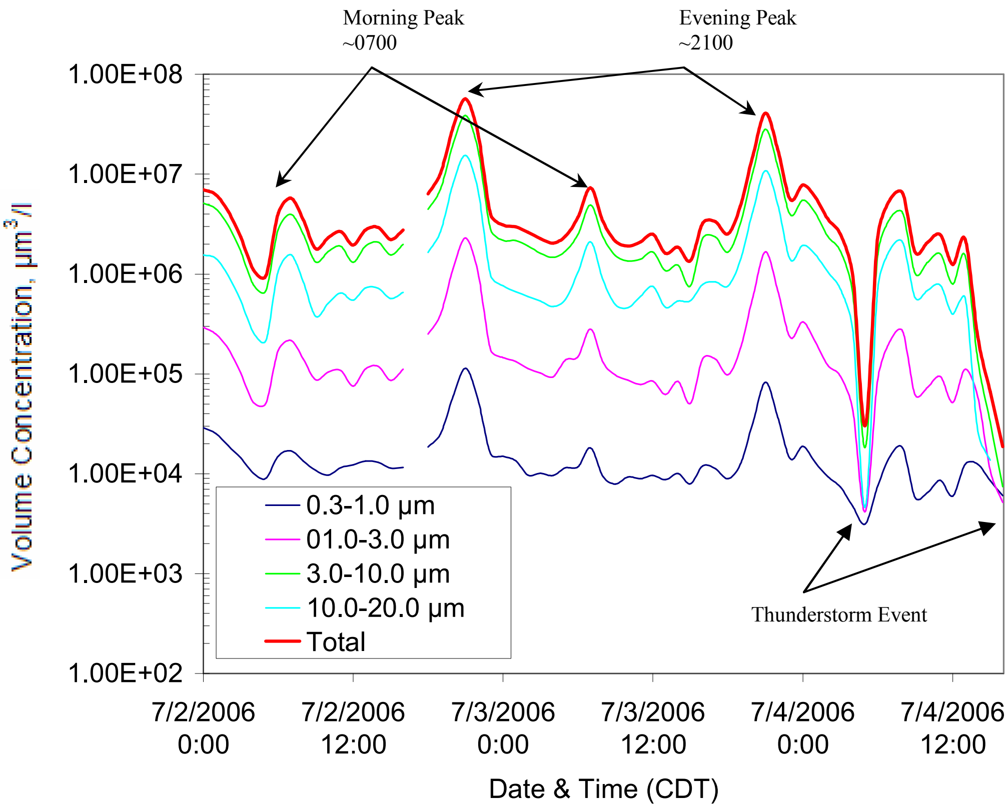

Figure 1. Volume concentration ($\mu m^3/l$) of agricultural particles as a function of time for 3 days

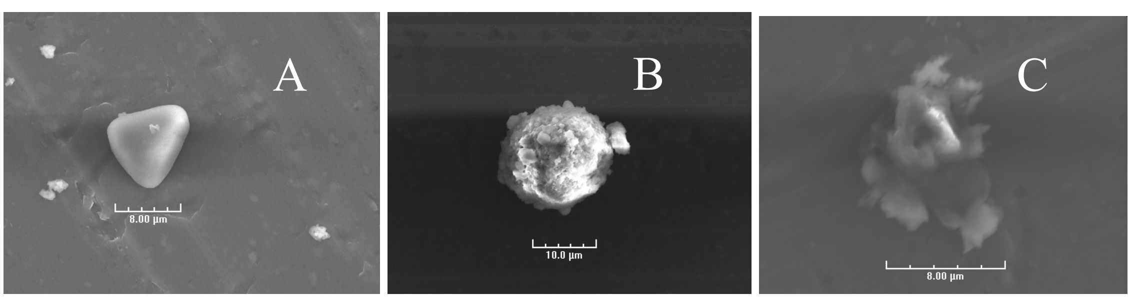

Figure 2. Images of representatives from the three types of particles observed: A. Smooth rounded particles, B. Rough-surfaced single particles with amorphous shapes, and C. agglomerations of multiple amorphous particles.

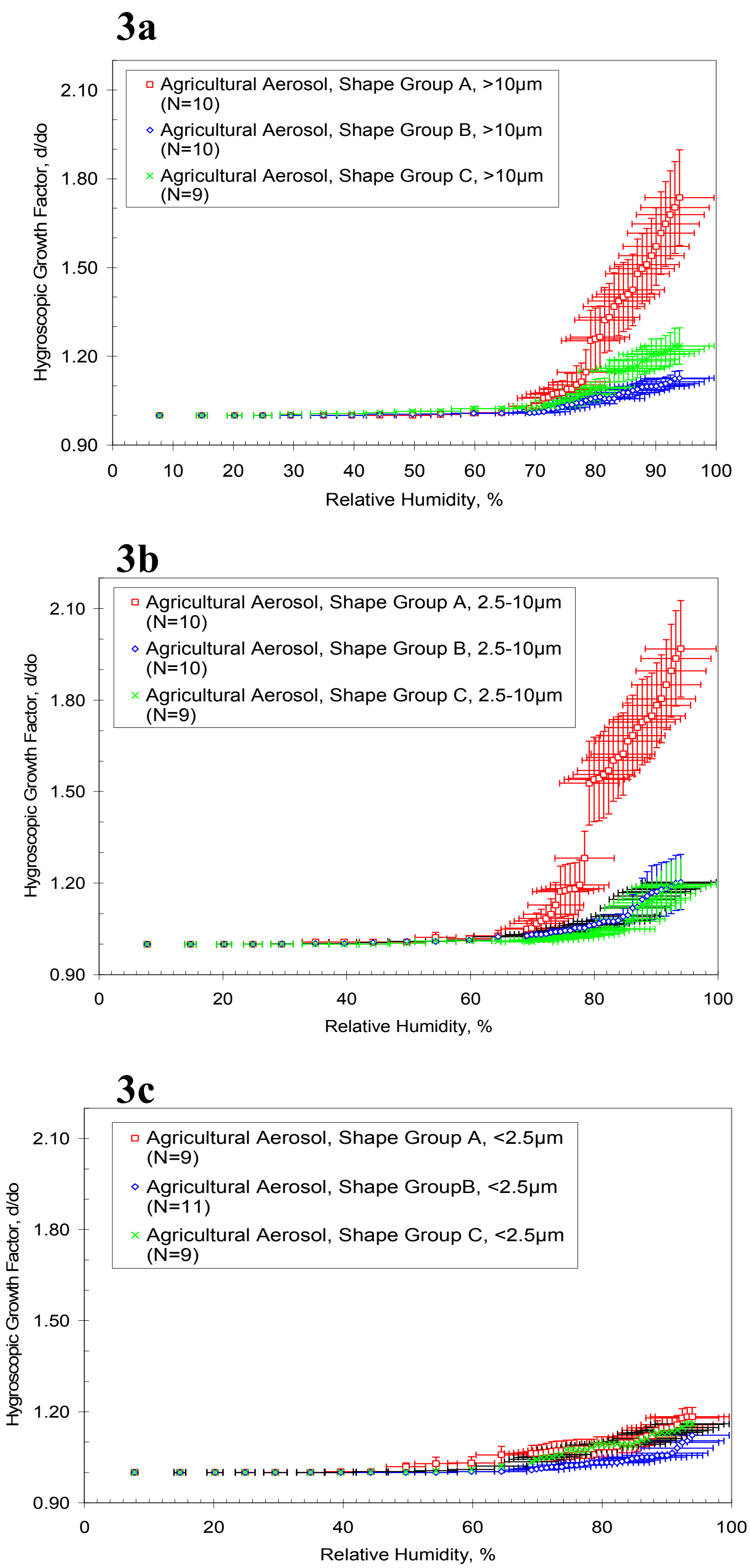

Figure 3. Hygroscopicity of agricultural particles determined by ESEM; (3a) for coarse agricultural particles [>10 µm], (3b) for intermediate agricultural particles [2.5 – 10 µm], (3c) for fine agricultural particles [<2.5 µm].

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