New Particle Formation (NPF) in a Suburban Mixed-Use Land Zone Site: Statistical Relationships Between Long Range Transport, Aerosol Composition, and Size Distribution

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ABSTRACT

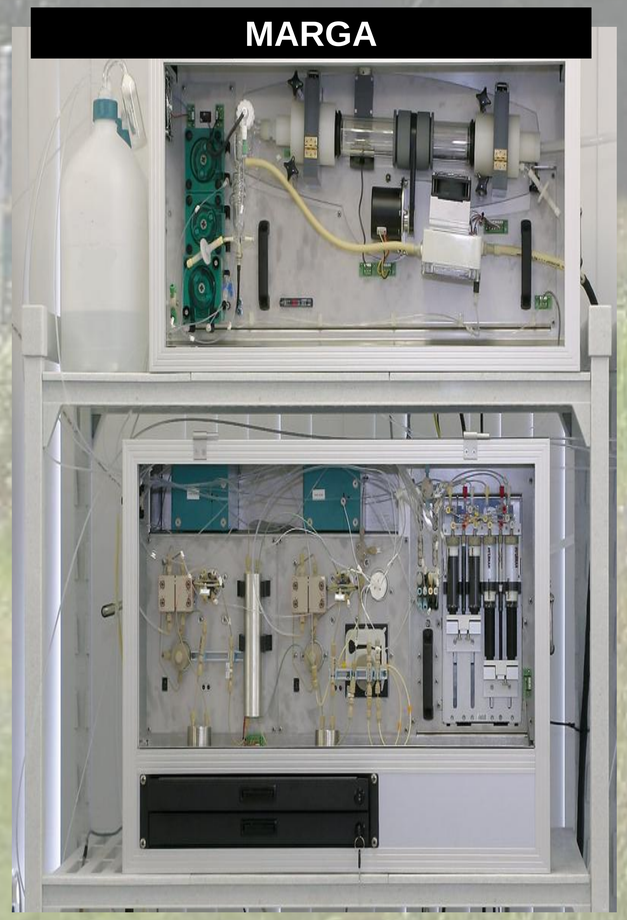
Aerosol chemical composition is one of the key parameters defining its physical behavior, particularly with regard to the properties important for climate impact. The formation and growth of atmospheric particles are currently not well understood. A prime motivation for this study was to derive a statistical relationship between meteorological, trace gas, and new particle formation (NPF). Directly measuring the composition of these newly formed particles is extremely difficult. This problem was approached indirectly by observing the different ambient air characteristics and relating the trace gas aerosol meteorologically interdependent behavior, hygroscopicity (water uptake), volatility (evaporation), and particle density to the formation of new particles. In this work, statistical and theoretical studies have been performed to investigate the formation and subsequent growth of atmospheric particles.

GOAL

The primary objective of this research is to compare measurements of aerosol microphysics to aerosol gas composition in ambient air. using principle Component Analysis (PCA). This statistical analysis may provide values for simplified model parameterization which can be used as a part of a larger atmospheric model to predict the concentration of climatically active particles.

LPC

MARGA



METHODS

To assess the microphysics and chemical processes that influence the production of anthropogenic and natural fine aerosols, in a suburban environment simultaneous observation were recorded for aerosol size distribution, inorganic composition, and precursor gas mixing ratios at a suburban field site near Beltsville, MD from June to September 2005. Gas and aerosol samples were taken using newly developed Monitoring Instruments for Aerosols and Gases (MARGA) instruments. The major water-soluble inorganic ions; nitrate (NO_3^-), sulfate (SO_4^{2-}), ammonium (NH_4^+), precursor gases were analyzed online with MARGA. To measure trace gases and particle distribution, a Thermo-Environmental Company (TECO) analyzers (ozone, SO_2, NOy, and NOx) , and a laser particle counter (LPC) were co-located at the site. Meteorological factors, such as wind speed and direction via NOAA HYSPLIT back trajectories were combined with the MARGA data and used to identify indicators that can be used to assign transport influenced pollution production. PCA and biplots were used to confirm the theoretical differences and similarities in the diurnal and local pollution conditions leading to NPF and increase in fine secondary aerosols concentrations. Biplots are two-dimensional plots showing a set of data points and a set of axes. The simplest biplot is to show the first two PCs together with the projections of the axes of the original variables.

The general form for the formula to compute scores (found in tables below) on a components created using PCA is:

$$c_1 \models \beta_{11}x_1 + \beta_{12}x_2 + \ldots + \beta_{1p}x_p$$

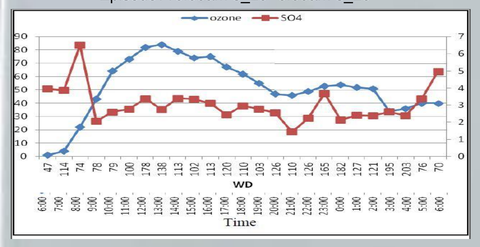
Where:

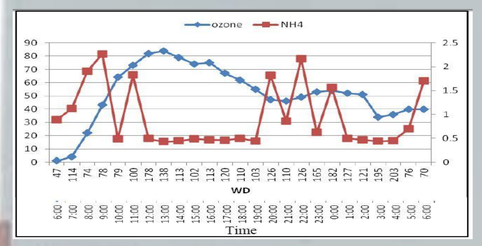
c_1= the subject's score on principal component 1 (the first component extracted)

B_{1p}= the regression coefficient (or weight) for observed variable p, as used in creating principal component 1

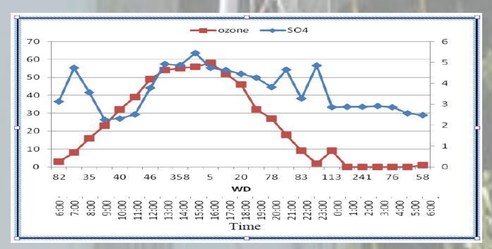
x_p= the subject's score on observed variable p

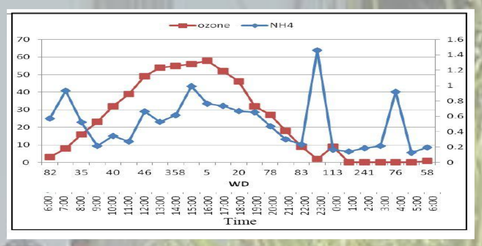
Episode A 6:00am 8_19- 6:00am 8_20





Episode B 6:00am 8_24- 6:00am 8_25



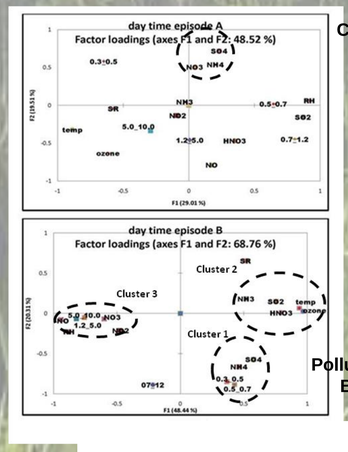


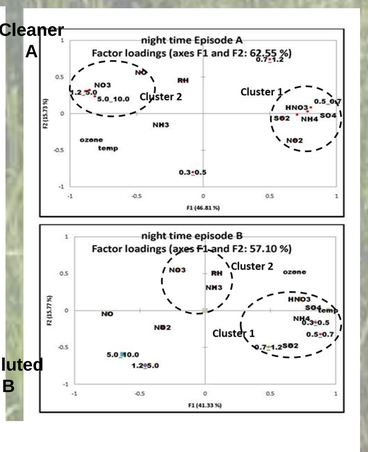
Variance %	29.0 %	19.5 %	**46.8 %**	**16.4 %**
	A daytime PC1	A daytime PC2	**A nighttime PC1**	**Nighttime PC2**
NO_2	-0.093	-0.135	**0.687**	**-0.365**
NO	0.174	-0.787	**-0.467**	**0.567**
NH_3	-0.030	0.046	**-0.317**	**-0.150**
SO_2	0.871	-0.154	**0.591**	**-0.058**
HNO_3	0.350	-0.468	**0.705**	**-0.013**
0.3-0.5	-0.648	0.582	**-0.078**	**-0.800**
0.5-0.7	0.644	0.020	**0.958**	**0.172**
0.7-1.2	0.807	-0.445	**0.500**	**0.744**
1.2-5.0	0.007	-0.458	**-0.886**	**0.308**
5.0-10.0	-0.291	-0.336	**-0.814**	**0.238**
NO_3^-	0.045	0.506	**-0.854**	**0.323**
NH_4^+	0.201	0.538	**0.784**	**0.030**
SO_4^{2-}	0.232	0.720	**0.808**	**0.086**
temp	-0.887	-0.319	**-0.715**	**-0.466**
RH	0.919	0.064	**-0.150**	**0.458**
SR	-0.575	-0.043		
ozone	-0.616	-0.630	**-0.839**	**-0.352**

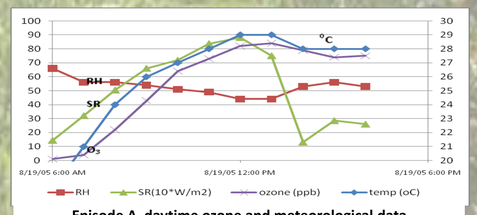
Variance %	48.4 %	20.3 %	**41.3 %**	**16.4 %**
	B daytime PC1	**B daytime PC2**	**B nighttime PC1**	**B nighttime PC2**
NO_2	-0.479	-0.211	**-0.326**	**-0.226**
NO	-0.942	-0.075	**-0.747**	**-0.040**
NH_3	0.517	0.183	**0.068**	**0.316**
SO_2	0.753	0.150	**0.655**	**-0.472**
HNO_3	0.794	0.009	**0.723**	**0.156**
0.3-0.5	0.366	-0.849	**0.847**	**-0.161**
0.5-0.7	0.427	-0.883	**0.882**	**-0.319**
0.7-1.2	-0.217	-0.886	**0.486**	**-0.494**
1.2-5.0	-0.821	-0.066	**-0.458**	**-0.743**
5.0-10.0	-0.757	-0.050	**-0.629**	**-0.595**
NO_3^-	-0.601	-0.068	**-0.211**	**0.553**
NH_4^+	0.461	-0.662	**0.830**	**-0.155**
SO_4^{2-}	0.577	-0.571	**0.829**	**0.043**
temp	0.937	0.066	**0.941**	**0.009**
RH	-0.879	-0.225	**0.091**	**0.511**
SR	0.514	0.655		
ozone	0.967	0.027	**0.685**	**0.530**

RESULTS

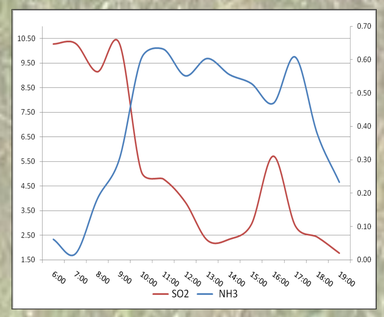
We identified two unique episodes that were regionally advected air masses were incident to the site with low wind speeds; the first was from August 18, 2005 to August 20, 2005 (Episode A) and the second was from August 23, 2005 to August 25, 2005 (Episode B). Diurnal variations in NO_3, SO_2, HNO_3, and NH_3 were observed with maximum concentrations during the day. Maximum sulfate and ammonium mixing ratio was recorded during the night 28.0 µg/m^3 and 9.90 µg/m^3, respectively. During Episode A the LPC recorded a maximum TSP count of 1.10 X 10^7 particles/cm^3 and Episode B the LPC recorded a maximum TSP count of 7.45 X 10^6 particles/cm^3. Yet, in 0.3-0.5, µm size range reached a maximum count of 3.64 X 10^6 particles/cm^3 during latter period and the 0.5-0.7 µm size range reached a maximum count of 5.23 X 10^6 particles/cm^3 during earlier period. The ambient measurements showed that sulfuric acid and sulfate aerosols dominated the new particle formation events. Also, the sulfuric acid/ammonia neutralization reaction product (ammonium sulfate) was detected in ambient air throughout this work.







Episode A daytime ozone and meteorological data



Episode B Times series NH_3 and SO_2 (ug/m^3)

Episode B Times series HNO_3 and SO_4 (ug/m^3)

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