

# Size-Resolved Properties of Atmospheric Aerosols in Sydney, Australia

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## Introduction

Size-resolved chemistry is important in determining the optical properties of atmospheric aerosols. It is these properties which affect the transmission of sunlight through the atmosphere, and thus are important for calculation of aerosol radiative forcing, 'atmospheric correction' of satellite images, as well as for local air quality and visibility.

In 2003 PM2.5 and PM10 aerosol samples were collected at four sites in the Sydney area using low volume samplers. UNSW is an urban site on the coast close to the CBD, Campbelltown is an urban site 50 km south-west of the CBD, Moss Vale and Berrima, are in rural areas just south of the Sydney Basin. Each site was sampled for several days in summer, autumn, winter and spring in order to examine the seasonal and spatial variations in aerosol composition. The chemical composition has been used to determine aerosol refractive index.

In 2008 a new sampling program commenced using a 10 stage MOUDI sampler. Sampling has been at UNSW, and at Merrylands, an urban site 25 km west of the CBD. This will provide better size-resolution for chemistry and thus more accurate refractive index estimates.

## Results for 2003

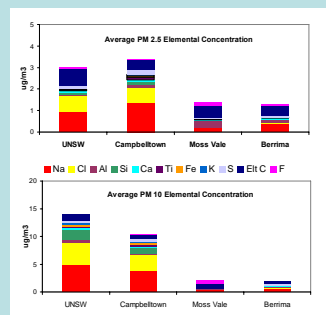


Figure 1

This shows the average elemental composition of PM2.5 and PM10 samples at each site for summer 2002/2003. The aerosol loading at the rural sites is much lower than for the urban sites. For all sites elemental carbon (Elt. C) is more prominent in the PM2.5 samples. Differences in elemental composition can be seen between size fractions, and also between sites.

Figure 2

This shows the seasonal and spatial variation in aerosol species for the PM2.5 and PM10-PM2.5 fractions. Composition shows clear seasonal and spatial differences. Elt. C is more significant in the PM2.5 fraction and soil in the PM10-PM2.5 fraction reflecting the differences in chemistry as a function of particle size.

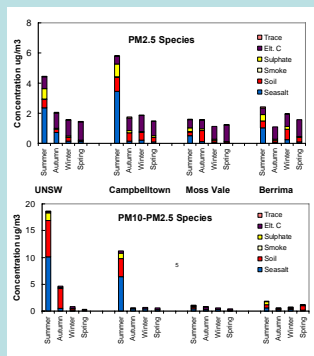
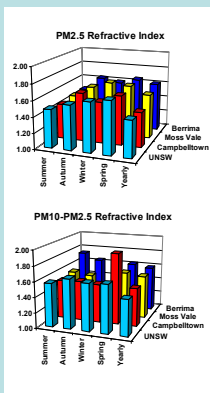


Figure 3

Chemical thermodynamic modelling was used to determine the aerosol species present and their concentrations. This information was combined with literature values of refractive index for each species to determine aerosol refractive index, using the partial molar refraction approach.

The figures on the left show the results for all sites. There are seasonal and spatial variations as well as differences between size fractions. These differences reflect variations in chemical composition.



## Discussion and Further Work

The results of the 2003 sampling program reveal that there are seasonal and spatial variations in aerosol chemistry across the Sydney Basin which result in variations in aerosol refractive index. The limited size resolution of the samples and the need to estimate PM10-PM2.5 composition by subtraction is a significant source of error for estimated properties.

Samples collected during the current sampling phase (2008) will be analysed in the same way as the 2003 samples to provide an estimate of refractive index. The next phase of analysis for the days presented here is the estimation of refractive index. More samples are being collected so that seasonal variations in chemistry and refractive index can be examined.

## Analysis

Elemental chemical composition of the samples was determined using Ion Beam Analysis. Elemental carbon was determined using the Laser integrating Plate Method.

Aerosol elemental composition is used to estimate the aerosol types present following Malm et al., (JGR, 99, 1347-1370, 1994)

$$\begin{aligned} \text{Sea Salt} &= 2.54 \text{ Na} \\ \text{Soil} &= 2.2 \text{ Al} + 2.49 \text{ Si} + 1.63 \text{ Ca} + 1.94 \text{ Ti} + 2.42 \text{ Fe} \\ \text{Smoke} &= \text{K} - 0.6 \text{ Fe} \\ \text{Sulphate} &= 4.125 \text{ S} \end{aligned}$$

The estimation of sea salt assumes that all sodium occurs as NaCl. This is not necessarily true. This is being looked at with the 2008 data.

The elemental chemistry is used as the input to a chemical thermodynamic model to determine the species present in the air at the time of sampling. The output from this is used to determine refractive index, using a molar refraction approach and refractive indices from the literature.

## Results for 2008

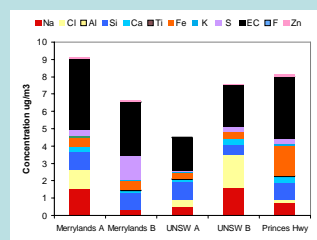


Figure 4

This shows the total elemental composition across all stages for each of the days sampled during April and May (autumn). The variations between sites are evident. The variations within sites reflect differences in the meteorological conditions. The UNSW samples show similar composition to 2003, as would be expected.

Figure 5

This shows the aerosol species on each stage for the Merrylands and UNSW sites.

There are clear differences in size-resolved chemistry. Soil and salt occur mainly in the coarse fraction and sulphate in the finer fraction.

These plots also illustrate the variability of aerosol composition at a single site.

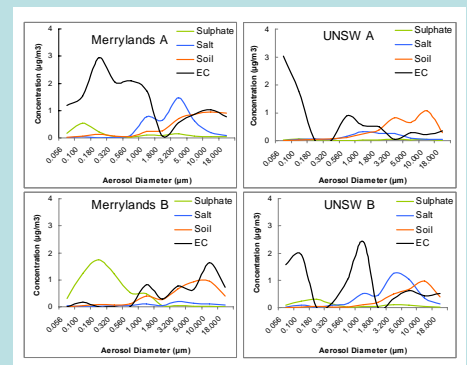
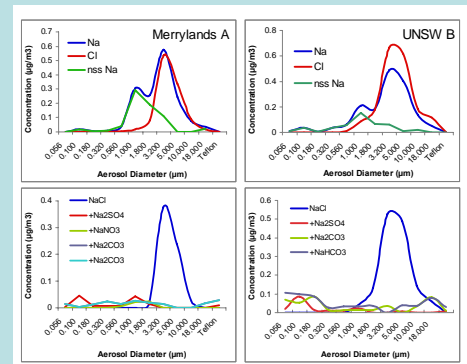


Figure 6

This shows the size distributions for Na, Cl and nss Na (top panels) and the size distributions of sodium compounds obtained from the thermodynamic model (bottom panels) for two days.

$$\text{nss Na} = \text{Na} - (\text{Na}/\text{Cl}) \times \text{Cl}$$

It is clear from these plots that sodium occurs in the form of sea salt in the coarse fraction, but in other forms in the finer fraction.



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