Contributions of biogenic secondary organic aerosol and biomass burning aerosol to PM10 loadings in the airshed of Melbourne, Australia

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Introduction

It is well established that wood smoke emissions from domestic heating contribute significantly to fine particle loadings during the autumn and winter in the airshed of Melbourne, Australia. However, the assessment of the relationship between direct primary wood smoke emissions and ambient particle concentrations in the region is hindered due to a limited number of chemical and physical measurements available in the region. In order to assess the contribution of residential wood smoke to the particle loadings of the airshed, an intensive winter-time aerosol characterisation campaign was carried out at the CSIRO Bayside Air Quality Station at Aspendale, Melbourne between the July and August 2004 and 2005. Additionally, summer-time aerosols were sampled during the December 2005 and January 2006.

Sampling and Analysis

Figure 1 shows the location of the CSIRO Marine and Atmospheric Research (CMAR) Bayside Air Quality Station (BAQS) at Aspendale in Melbourne. The site is located in a residential area 25 km south of the city of Melbourne in Victoria Australia. The site is influenced by vehicle emissions, marine aerosol, light industry and residential emissions (including emissions from wood heaters used for domestic heating between May and September). The station is equipped to measure the concentration of the criteria pollutants defined in the of Australian National Environment Protection Measure for Ambient Air Quality (NEPM), as well detailed measurements of aerosol chemical and microphysical properties, including size-resolved chemical composition, detailed organic speciation, aerosol hygroscopic growth, the concentration of volatile components, aerosol scattering coefficient and aerosol number size distributions.

Samples from a PM10 high volume aerosol sampler were used for tracer analysis. The high volume sampler (HVS) operated in this study was an Ecotech 3000 series high volume sampler with a Gold-Top PM10 inlet.

Samples from a PM10 high volume aerosol sampler were analysed using High Performance Liquid Chromatography coupled to Electrospray Ionisation Time of Flight Mass Spectrometery (HPLC/ESI-TOFMS), and the concentrations of woodsmoke tracers and SOA tracers were determined In addition a thermographic method determined the ratio of organic carbon to elemental carbon (OC/EC). Water Soluble Organic Carbon (WSOC) was determined using a Shimadzu TOC analyzer.

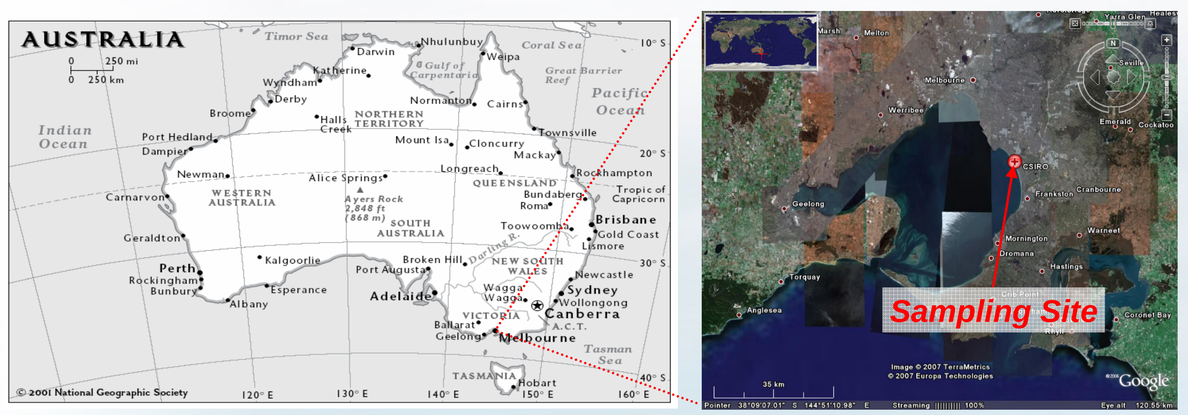


Figure 1. *Map of Australia and the location of the CSIRO Bayside Air Quality Station at Aspendale*

Melbourne is:

- Second most populous city in Australia
- 3.7 million inhabitants
- Mild climate but it can get as hot as 40˚C in summer and cold as 4˚C in winter
- Bushfires in summer
- Domestic firewood commonly used in winter
- BVOC emitters nearby (national parks)

References

NASA Fire Information for Resource Management System (FIRMS).
Draxler R., Rolph, G., 2003. HYSPLIT (Hybrid Single Particle Langrangian Integrated Trajectory) Model access via NOAA ARL READY website (http://www.arl.noaa.gov/ready/hysplit4.html). NOAA Air Resources Laboratory, Silver Spring, MD.

Results and Discussion

Figure 2 shows the day-to-day variation of PM10, OC, WSOC and EC concentrations and the sum concentrations of biomass burning and SOA tracers. Figures 4 and 5 show the levels of PM10 and carbonaceous particles versus SOA and anhydromonosaccharides, respectively. These figures show the followings:

- High PM10 concentrations were mostly associated with woodsmoke (winter), bushfires and SOA (summer).
- Even with a strong influence of domestic wood burning, the 24 hour average PM10 concentrations did not exceed 50 µg m^{-3} during the winter campaigns whereas the bushfire on 25 January 2005 easily raised the PM10 level over 50 µg m^{-3}.
- Virtually no anhydormonosaccharides, substituted phenols and resin acids in summer months.
- Higher concentrations of monoterpene oxidation products (SOA tracers) in summer months.
- Relatively high levels of monoterpene SOA tracers were also observed from the days with a high domestic firewood contribution, possibly formed from residual monoterpenes in firewood. Nevertheless, a higher correlation between OC and SOA was found in summer.
- Lower woodsmoke contributions were found in winter 2005 than 2004. This is partly due to the higher average temperature in winter 2005. It was the warmest winter since 1975 (average 1.6˚C above mean temperature).

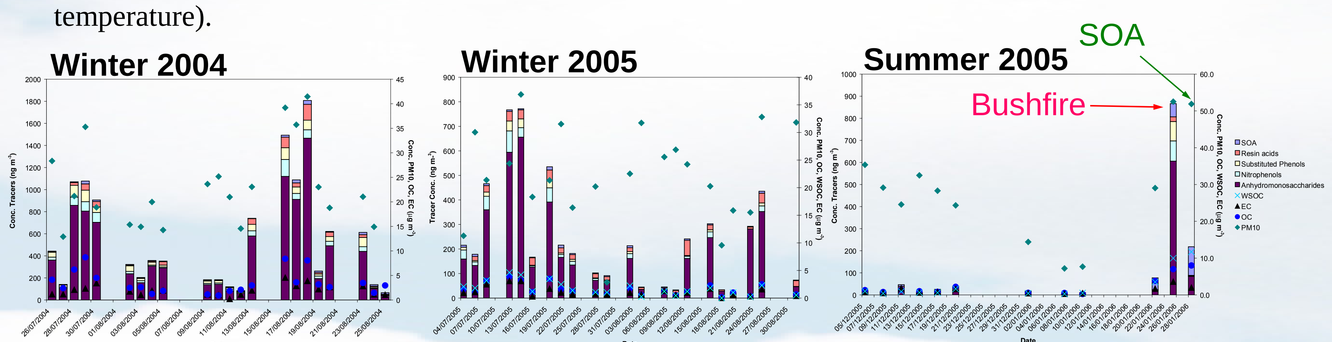
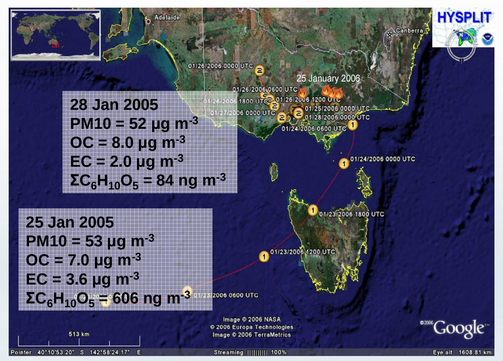


Figure 2. *Concentrations of OC, WSOC, EC and PM10 and sum concentrations of biomass burning and SOA tracers for winter 2004, 2005 and summer 2005 samples.*



Extremely high PM10 concentrations were observed on 25 and 28 January 2005. The tracer analysis shows a strong influence of biomass burning on 25 January whereas 28 January showed a higher contribution of SOA species. Back trajectories and satellite imagery also support these findings. A bushfire event on 25 January in the North-East of Melbourne corresponds to the high levels of PM10 and biomass burning traces and a stagnant air mass over national parks on 28 January corresponds to the high SOA level (Figure 3).

Figure 3. *Back trajectories and satellite derived fire spots on 25 and 28 January 2005.*

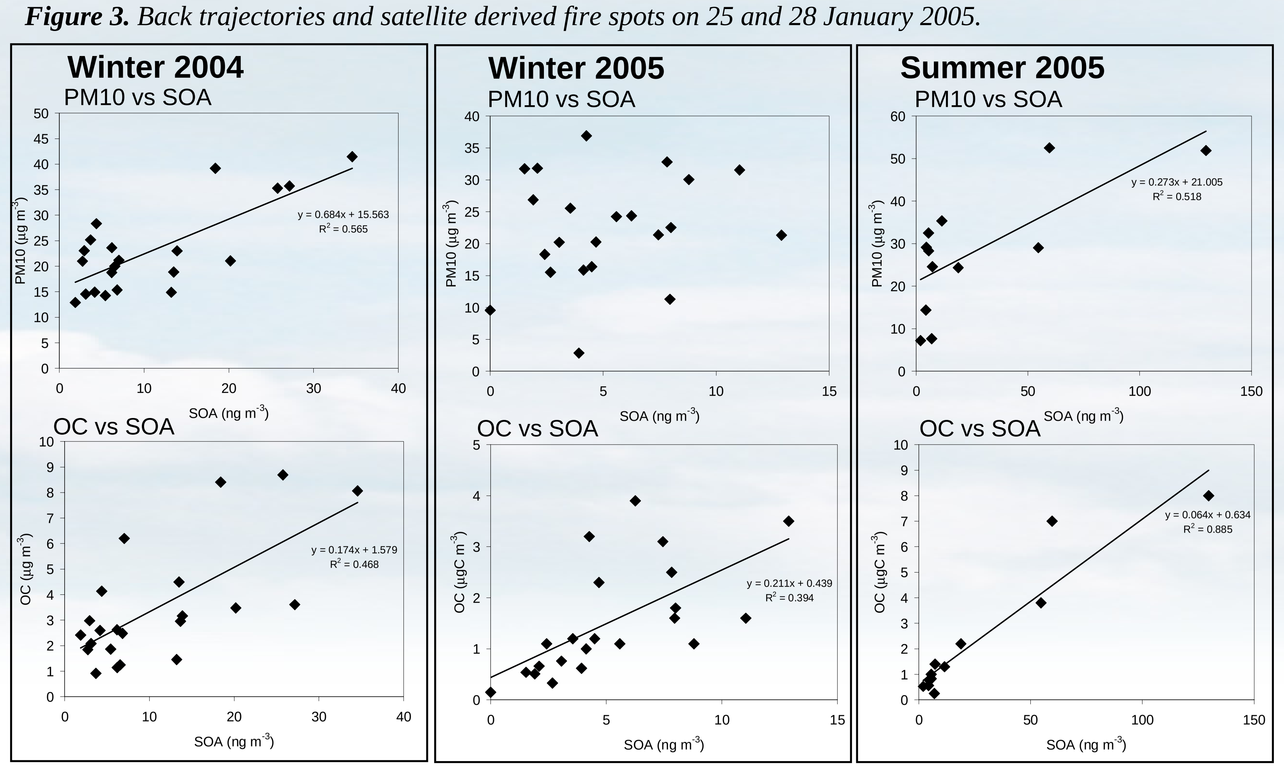


Figure 4. *PM10 and OC concentrations as a function of sum of SOA tracer concentrations*

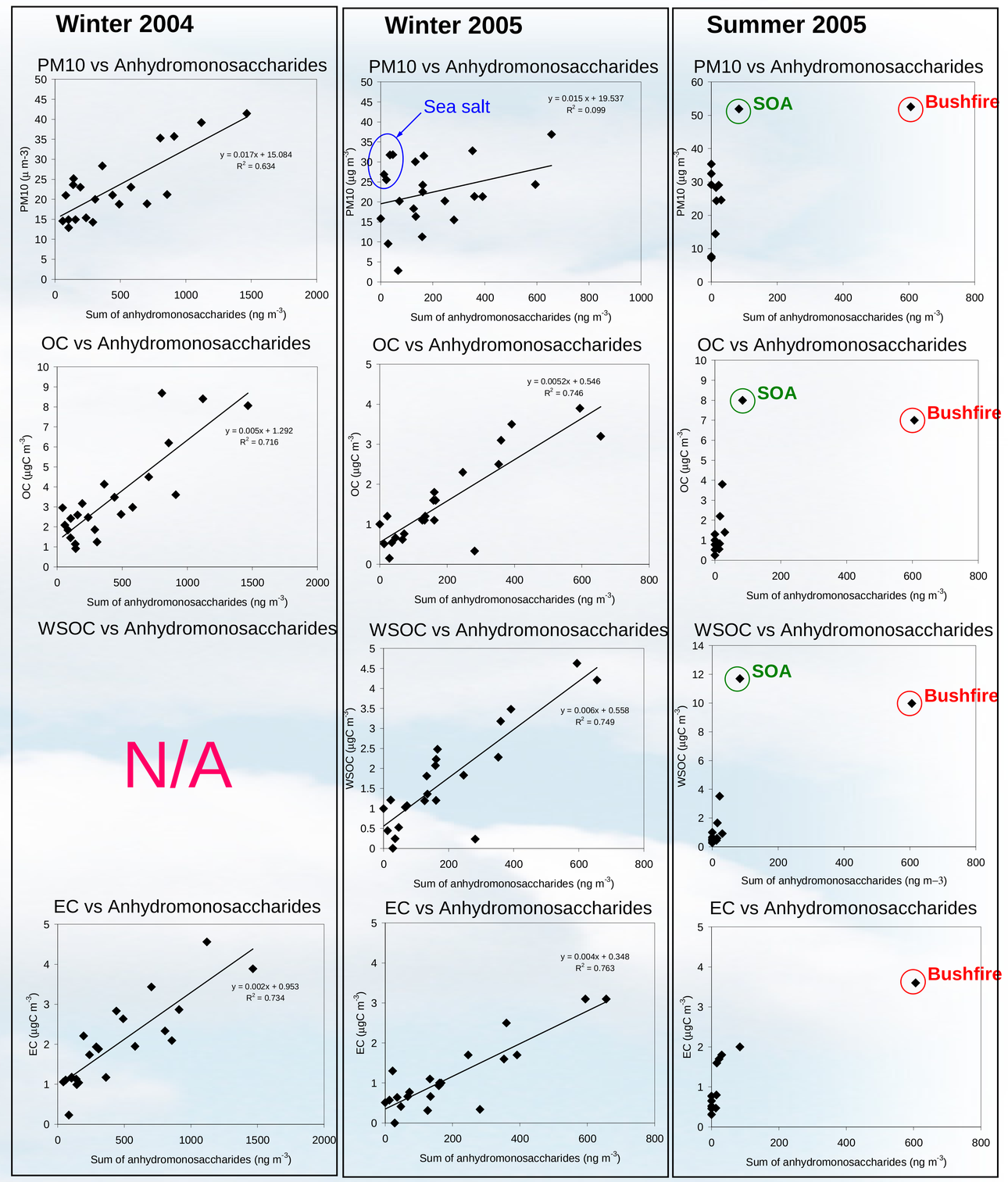


Figure 5. *PM10, OC, WSOC and EC concentrations as a function of sum of anhydromonosaccharide concentrations*

Summary

These regression relationships indicate the following:

Winter

•100 ng m^{-3} increase in anhydromonosaccharrides corresponds to 1.5-1.7 µg m^{-3} increase in PM10.
  •This corresponds to approx. 7kg/capita/day firewood consumption
  •Or 1 kg/capita/day firewood consumption brings 1.1 µg m^{-3} more PM10

Summer

•Generally low organics
•However, bushfires and SOA can contribute significantly to PM10 and OC

The NEPM limit was not exceeded during the winter campaigns even with the emission from domestic wood heating. Nevertheless, the emissions from domestic wood heating are significant source of PM10 loadings in the region.