Prevalence of Freshly Generated Particles during Pollution Episodes in Santiago de Chile

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A winter campaign was carried out in Santiago de Chile the year 2012 in two urban sites that can be considered representative for most of the city in order to characterize formation of primary and secondary PM1.0 during episodes. A noticeable increase in most of the primary components of PM1.0 (black carbon and organics) and primary gases (CO and NO) was observed during days in which the average PM1.0 concentration was higher than 50 $\mu g/m^3$ (episode). A small increase or no change was observed in the secondary pollutants (NH_4, NO_3, SO_4 and NO_2) at night during these episodes. Positive Matrix Factorization was used to extract four components from the ACSM data. The freshly generated components (HOA and BBOA) showed a clear increase at night during episodes, while the aged fraction of organic aerosol (LV-OOA and SV-OOA) showed a smaller increase or a decrease at night during episodes. Correlation of HOA and BBOA components with primary pollutants was also high, indicating that freshly created aerosols (HOA, BBOA and BC) are in large part responsible for the increase in pollution at night during episodes in Santiago de Chile.

Measurements were performed during a period that was long enough to capture several high pollution episodes during fall and winter. Measurements with an Aerosol Chemical Speciation Monitor (ACSM) and a black carbon monitor, indicate that on average in Santiagoabout 85% of $PM_{2.5}$ is contained in the ultrafine fraction (d < 1 μm). The largest fraction measured by the ACSM at Usach site corresponds to organics with an average concentration of 15.4 μg/m3 followed by BC with 7.0 μg/m3. These two fractions have a relatively large correlation of $R^2 = 0.51$, n = 2392, because some of the sources are the same. BC is of primary origin and is emitted by vehicles, diesel engines, wood burning, cooking, etc. Organic aerosols are also emitted mostly by the same sources (although with different emission factors) but it has also secondary origin. The average concentration for NO3 is 5.2 $\mu g/m^3$ and 2.7 $\mu g/m^3$ for NH^4 between March and July. The correlation coefficient between these components is very high $R^2 = 0.85$. Nitrate forms several compounds with other elements in the atmosphere (KNO_3, HNO_3, $NaNO_3$, NH_4NO_3, $Ca(NO_3)_2$, etc.), however, the high correlation between NH_4 and NO_3 indicates that most of the nitrate in the air of Santiago is in the form of ammonium nitrate (NH_4NO_3).

A four factor statistical analysis using positive matrix factorization (PMF, Paatero and Tapper, 1997) has been performed with the ACSM data to separate the main components of organic aerosol. The four Organic Aerosol (OA) components have been plotted as function of time in Figure 1. The lowest total concentration occurs in March, which is the last month of summer and increases as winter approaches. The main reason for the higher concentration in winter is the lower temperature which forms stronger inversions and the lower wind speed which prevents dispersion of contaminants. All factors grow from March to June, but BBOA is the factor that increases the most, from 0.34 μg/m3 (3.3%) in March to 4.64 μg/m3 (45.8%) in June. The growth in all components is related to a smaller atmospheric boundary layer, but BBOA must be also related to an increase in the use of wood stoves. In Santiago, wood burning is used mainly for space heating, which increases as temperature decreases.

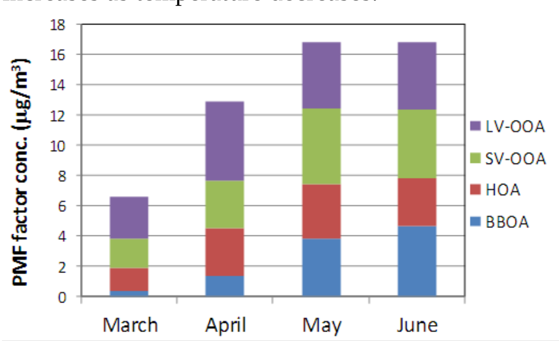

Figure 1. Evolution of the organic components of $PM_{2.5}$ from March to June of 2012.

The daily profile of the four factors has been calculated for the whole period and separated in days with and without episodes. Results shows that the primary organic components, HOA and BBOA, have higher concentrations values at night during episodes. If the day average is calculated from 6 am to 7 pm and the night average is calculated from 8 pm to 5 am of the next day, then the night average is 88% higher for HOA and 98% higher for BBOA during episodes. On the other hand, the older organic components, SV-OOA and LV-OOA show a smaller increase or even decrease at night during episodes.

References.

Paatero, P. and Tapper, U. (1994). "Positive Matrix Factorization", Environmetrics, 5: 111–126.