Assessing the Wintertime Contribution of Biomass Smoke to Organic Aerosol at 15 Sites in Switzerland by Analysing Filter Samples Using Aerosol Mass Spectrometry

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In winter, domestic wood burning yields high concentrations of organic aerosol (OA) in the alpine regions and urban areas such as Grenoble, Zurich and Milano (Lanz et al. 2010; Piazzalunga et al. 2011). Biomass burning contributes on the order of 15% of submicron OA even in the megacity of Paris (Crippa et al. 2013). Due to the carcinogenic potential of biogenic smoke, it is crucial to examine its contribution and sources in different regions in order to design effective mitigation strategies. Such an analysis requires measurements capable of quantitatively distinguishing OA sources, distributed over a broad spatial scale and with sufficient spatial density to elucidate regional differences.

Aerosol mass spectrometer (AMS, Aerodyne) measurements of OA and subsequent application of positive matrix factorization (PMF) have proven capable of quantifying the biomass burning fraction (BBOA), even within a mixed aerosol containing other primary sources such as traffic (hydrocarbon-like OA, HOA), and secondary oxygenated OA (OOA), formed in-situ in the atmosphere via the oxidation of volatile organic compound precursors (e.g. Lanz et al. 2007). However, the cost and complex maintenance required by this instrument makes impractical its systematic long-term deployment at sufficient sites to determine regional characteristics. To overcome these limitations, we have developed a method for the analysis of conventional aerosol filter samples using high-resolution AMS measurements. Such samples are relatively easy and inexpensive to collect and store, and are already routinely collected at many air quality stations.

The analysis method consists of water extraction of the particulate material from quartz filters and subsequent atomization of the resulting solutions into the AMS. The extraction efficiency is estimated as ~80% and the mass spectra obtained by this methodology are very similar to the corresponding on-line measurements considering different settings (e.g. different sites and different seasons).

We present here the first application of this technique to filter samples collected during 2 consecutive winters (2008 and 2009) at 15 stations in Switzerland with different exposure characteristics (including a complete yearly cycle for one of the stations). Data are analysed with the multilinear engine ME-2 (Paatero 1999), with a toolkit for Igor, which allows to constrain certain sources when running a PMF, and combined with other measurements, including organic and elemental carbon (OC/EC), ions, levoglucosan (marker for biomass burning), and radiocarbon content (^{14}C), to provide an improved estimation of the biomass smoke contribution to OA (Figure 1). BBOA contribution and emission profiles at different stations will be discussed and related to the prevailing meteorological and combustion conditions.

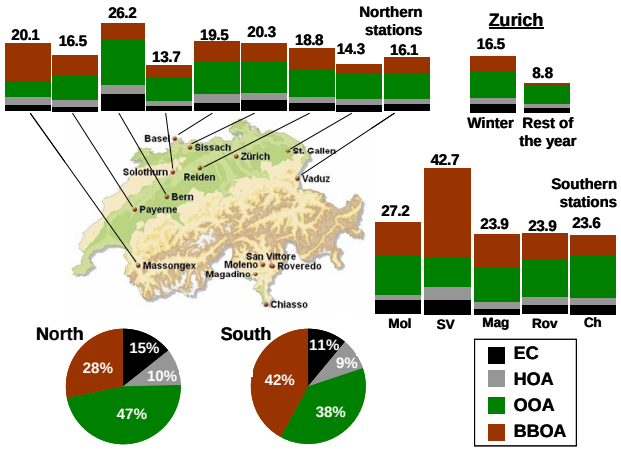

Figure 1: PMF applied to off-line AMS measurements presenting the average contributions of EC, HOA, BBOA and OOA at 15 different sites in Switzerland. The comparison shows that the BBOA contribution is two times higher in the southern part of Switzerland, presumably related to less efficient burning conditions in this region.

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