Fossil and non-fossil sources of OC and EC in Switzerland for winter-smog episodes

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Persistent inversion conditions may occur in Switzerland in the plateau and in Alpine valleys during winter. Such winter-smog episodes may lead to high concentrations of particulate matter with an aerodynamic diameter <10 µm (PM_{10}) exceeding the legal daily limits of 50 µg/m^3 over several days to weeks. As such conditions may cause acute health effects, the emission sources of PM in general and of carbonaceous aerosols in particular are of special interest for these episodes. A substantial contribution of biomass burning was indicated in previous campaigns in Switzerland (Szidat 2009).

From winter 2007/2008 to winter 2011/2012, several stations of the Swiss federal and cantonal air monitoring programs provided quartz fibre filters for 5 days per winter (simultaneous collection for all stations) with high PM_{10} concentrations (Figure 1). Samples were analysed for major anions and cations as well as organic carbon (OC) and elemental carbon (EC) concentrations.

Figure 1. Map of the study. Stations marked in red participated only during one or two winters.

Fossil and non-fossil sources were apportioned for all filters by measurement of the long-lived radioisotope ^{14}C (radiocarbon) based on the fact that fossil materials are extinct in ^{14}C due to its age, where as fresh plants contain radiocarbon on the contemporary level (Szidat *et al*. 2006). ^{14}C analysis was performed on OC and EC separately, because both fractions typically originate from diverse sources with different fossil/non-fossil shares EC originates only from combustion of fossil-fuels and biomass burning. OC can be emitted as primary organic aerosol from biogenic sources, wood burning and fossil fuel combustion or can be formed in the atmosphere as secondary organic aerosol. In total, >500 individual ^{14}C determinations were conducted.

Special emphasis was laid upon an optimized isolation procedure for EC, as the ^{14}C value of this fraction directly reflects the biomass-burning contribution of the emissions. EC isolation was performed with the new protocol Swiss_4S, which combines steps of water extraction, combustion in oxygen and evaporation in helium for complete OC separation with online monitoring of the optical transmission (Zhang *et al*. 2012).

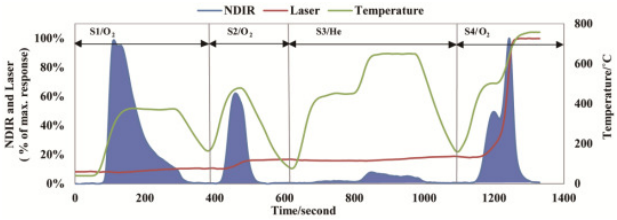

Figure 2. Thermogram based on the Swiss_4S protocol for isolation of EC for ^{14}C analysis (Zhang *et al*. 2012).

On the average, the non-fossil fractions of OC were larger than 75% for each station, which indicates that primary or secondary traffic emissions contributed only to a minor extent during the winter-smog episodes. This was even valid for the motorway (Reiden, Moleno) and kerbside stations (Bern), which demonstrates the importance of regionally mixed over local emissions. ^{14}C analysis of EC revealed that biomass burning contributed on the average by one to two thirds to the total burden of this carbonaceous aerosol fraction depending on the station characteristics: whereas traffic-related sites showed smaller proportions, dominating biomass-burning emissions were observed in Alpine valleys, where residential wood heating is common. In this work, we will present final results and discuss in detail the contribution of biomass burning for winter-smog episodes in Switzerland and its trend over the five years of the study.

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