Source apportionment in a complex environment by developed Positive Matrix Factorization: advantages and limitations

F. Chevrier[1-2], I. Ježek[3], G. Močnik[3-4], G. Brulfert[5], J.-L. Jaffrezo[1] and J.-L. Besombes[2]

[1]LGGE, Université Grenoble Alpes, Grenoble, F-38000, France
[2]LCME, Université Savoie Mont Blanc, Chambéry, F-73000, France
[3]Aerosol d.o.o., 1000 Ljubljana, Slovenia
[4]Jozef Stefan Institute, 1000 Ljubljana, Slovenia
[5]Air Rhône-Alpes, Bron, France
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Presenting author email: florie.chevrier@lgge.obs.ujf-grenoble.fr

For some years, PM_{10} concentrations frequently exceed European air quality limit values in Alpine valleys during winter. In the Arve valley (including the town of Chamonix), in France, public authorities decided to put together a plan of abatement measures (Atmospheric Protection Plan) including strong actions to reduce the impact of domestic biomass burning on air quality. In order to evaluate the impact of these measures, it is important to quantify the sources affecting the PM_{10} concentrations in these complex topographical and meteorological conditions, and to assess the robustness of commonly used methodologies for source apportionment. The DECOMBIO program was implemented for this purpose.

An extended campaign took place in three sites representing the main parts of the Arve valley: Marnaz, Passy, and Chamonix. On all three sites, a detailed chemical characterization of the PM_{10} chemistry was performed with off-line samples every third day over a year including the measurements of many inorganic, organic and trace metal tracers. At the same sites, Aethalometers AE33 were deployed and have been operational for 3 years.

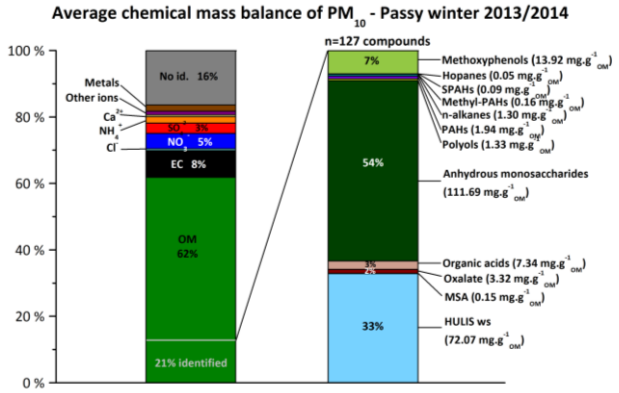

Figure 1. Average composition of winter PM_{10} in Passy

Figure 1 shows the average chemical composition of PM_{10} in winter on Passy, one of the most impacted sites by residential biomass burning in the Rhône-Alpes Region.

Source apportionment for the chemical data was performed using the PMF 5.0 (Paatero et and Tapper, 1994). Several steps were performed in order to rebuild as well as possible the various sources of PM_{10}. The model's performance, in the context of this valley was first tested with compounds classically used in literature (OC, EC, metals, ionic species) (Rizzo and Scheff, 2007; Waked et al., 2014), then specific organic markers were added (levoglucosan, polyols, MSA, hopanes, sulfur PAHs) (Golly, 2015) and finally, the results of the BC source apportionment using the Aethalometer model (Sandradewi et al., 2008) were added. Owing to the atmospheric dynamic of this valley, and similar environments, the pollution events are strongly associated with temperature inversions, leading to difficulties in source apportionment. External constrains on the factor solutions were then added in the model to get round the collinearity problems.

Results of this source apportionment showed predominance of biomass burning source during winter with different contributions at the three sites (about 32 % in the beginning of the valley and 43 % in the end). Usually, specific organic markers are enough to identify well-defined sources like biomass burning, vehicular exhaust, industrial processes or soil biogenic source but not in case of this valley where the very specific atmospheric dynamic in winter induces a mixing of some factors. Introducing on-line BC_{wb} measurements results leads to improve the direct deconvolution of PM_{10wb}.

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