Cutting-edge approaches for aerosol source apportionment by receptor modelling

R. Vecchi[1,2]

[1]Department of Physics, Università degli Studi di Milano, Milan, 20133, Italy
[2]National Institute of Nuclear Physics, INFN-Milan, Milan, 20133, Italy
Keywords: source apportionment, receptor modelling, multi-time, multi-parameter, 3D, DN-PMF.
Associated conference topics: keynote
Presenting author email: roberta.vecchi@unimi.it

Over the last decades, the development of high time resolution instrumentation allowed an increasing detailed chemical and physical characterisation of atmospheric aerosol e.g., in terms of chemical composition, size distribution, and optical properties. In field campaigns a huge variety of parameters are typically measured at different time resolutions but it is still challenging to use them together in a unique modelling process.

Source apportionment (SA) methods based on chemical composition datasets have been widely used by the aerosol community to retrieve the impact of different sources on aerosol ambient concentrations e.g. by means of receptor modelling (Belis et al., 2019). Nevertheless, at the state of the art still few source apportionment studies combine high time resolution measurements or multi-parameter datasets as input to the receptor model.

This keynote presentation aims at presenting advanced receptor modelling approaches which fully exploit the information contained in the data collected in field campaigns by a variety of instruments at different time resolutions.

Indeed, the flexibility of the Multilinear Engine ME-2 program (Paatero, 1999) allows a number of improvements in SA studies such as:

- The *multi-time receptor modelling* approach (originally introduced by Zhou et al., 2004; and further implemented e.g. by Crespi et al., 2016) which uses input data with their native time resolution so that the detailed temporal patterns are maintained together with the comprehensive chemical characterisation, which is often retrieved on low-time resolution samples. This kind of analysis helps in better decoupling factor profiles and the temporal patterns of the identified emission sources can be reconstructed at a time resolution equal to the lowest sampling interval present in the dataset.
- The *multi-parameter receptor modelling* approach using e.g. optical data together with chemical variables was firstly introduced by Hopke et al. (2012) with the delta-C parameter as a tracer of wood combustion. The approach was then implemented inserting multi-wavelength absorption coefficients by Forello et al. (2019) who retrieved, as original result, the source-dependent Absorption Ångström Exponent (AAE) thus overcoming the limitations imposed by the assumptions needed by current optical SA methods like e.g. the Aethalometer model; indeed, optical SA refers to a simplified 2-sources situation (with fossil fuel and biomass burning emissions) and imposes a-priori AAE values thus increasing the uncertainty on the results.
- The *three-way receptor modelling* approach is still rarely applied in the literature although it can exploit the detailed information contained in the size segregated aerosol composition (see e.g. Bernardoni et al., 2017). The output provides size distributions and size-segregated chemical profiles for the identified sources, which are key information for health protection actions and the development of suitable and effective pollution abatement strategy.
- The *dispersion normalised Positive Matrix Factorisation* (DN-PMF) approach has been recently introduced by Dai et al. (2020) and implemented by Sofowote et al. (2021) for multi-time resolution datasets. This method aims at decoupling the effect due to emission strength variability and to atmospheric dispersion on the concentration variations observed in ambient measurements by scaling measured concentrations with the ventilation coefficient.

In this presentation, basic theory and examples from different field campaigns will be presented to highlight strengths and weaknesses of each approach.

The author is grateful to present and past research group members for the precious collaboration and the huge efforts put in implementing new approaches.

Belis et al. (2019). *EUR 29816 EN*, Publications Office of the European Union, Luxembourg.
Paatero, P. (1999). *J. Comput. Graph. Stat.* **8**, 854–888.
Zhou et al. (2004). *Atmos. Environ.* **38**, 4909–4920.
Crespi et al. (2016). *Sci. Total Environ.* **541**, 502–511.
Hopke et al. (2012). *J Air Waste Manag. Assoc.* 2(8), 880-7.
Forello et al. (2019). *Atmos. Chem. Phys.* **19**, 11235–11252.
Bernardoni et al. (2017). *Environ. Pollut.* **231**, 601-611.
Dai et al. (2020). *Environ. Sci. Technol.* **54**, 9917–9927.
Sofowote et al. (2021). *Sci. Total Environ.* **761**, 143225.