Light extinction estimates using the IMPROVE algorithm: The relevance of site-specific coefficients.

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Atmospheric aerosol and gases affect visibility by scattering and absorbing the incoming radiation (Watson, 2002; Pitchford *et al*, 2007). While the role of gases is relatively well understood, the effect of particulate matter (PM) is more complicated to be assessed since it depends on several factors such as particles size distribution and chemical composition as well as meteorological parameters (e.g. relative humidity – RH).

The U.S. Interagency Monitoring of Protected Visual Environments (IMPROVE) network proposed a method to retrieve atmospheric light extinction coefficient (b_{ext}, Mm^{-1}) in national parks from compositional and meteorological data (Malm *et al*, 1994; Watson, 2002). The result of this approach (often called chemical light extinction) allows the evaluation of visibility indicators such as visual range (VR) via the Koschmieder equation $VR=3.912/b_{ext}$.

In this study we tailored the IMPROVE equation using site-specific dry mass extinction efficiencies and hygroscopic growth functions in order to obtain b_{ext} estimates which better reflect the typical atmospheric characteristics of the sampling site and period. The revised formulation was tested for the first time in the urban area of Milan, for two weeks during the winter season in 2015. Moreover, it was applied to a large and fully characterized dataset referred to PM_1 samples collected in winter 2012.

Following the IMPROVE algorithm (Malm *et al*, 1994; Watson, 2002; Pitchford *et al*, 2007) the chemical light extinction equation used in this work was:

b_{ext} = k_1 x f_1(RH) x [AMSUL] + k_2 x f_2(RH) x [AMNIT] + k_3 x f_3(RH) [OM] + k_4 x [fine soil] + b_{ap} + 0.60 x [coarse mass] + 0.33 x [NO_2] (ppb) + Rayleigh scattering,

where inputs are the concentrations of the five major PM components (ammonium sulphate - AMSUL, ammonium nitrate - AMNIT, organic matter - OM, fine soil, coarse mass) in $\mu g\ m^{-3}$, NO_2 concentration (in ppb), Rayleigh scattering by gases (Mm^{-1}) and aerosol light absorption coefficient (b_{ap}, Mm^{-1}) measured with a home-made polar photometer on PTFE filters.

Dry mass extinction efficiencies (k_1-k_4, $m^2\ g^{-1}$) for every chemical component of interest were calculated considering size distributions measured in Milan (Vecchi *et al*, 2012), particles densities and complex refractive indices (Watson, 2002). Furthermore, hygroscopic growth functions f_i(RH), defined as the ratios between ambient and dry aerosol scattering coefficients (b_{sp}), were also calculated (using hygroscopic growth factors taken from the literature) and were applied to those PM components (AMSUL, AMNIT and OM), whose b_{sp} are enhanced by their water uptake at medium-high RH values. It is worthy to note that in the original IMPROVE algorithm (Malm *et al*, 1994; Watson, 2002) the hygroscopic growth function f(RH) is calculated referring only to AMSUL hygroscopic properties and it is applied also to AMNIT, whereas OM is considered as non-hygroscopic.

Non-negligible discrepancies were found between tailored dry mass extinction efficiencies and the original IMPROVE ones. Furthermore, differences between calculated f_i(RH) and IMPROVE hygroscopic growth function were found.

The methodology here described was applied to a PM_1 dataset thus retrieving the extinction contribution given by the different PM_1 components as well as by the major aerosol sources. Both methodological and experimental results will be shown in the presentation.

This work shows that – due to the large variability in size distributions and aerosol composition at sites with different characteristics (e.g. urban, industrial, rural) – it is advisable to calculate site-specific k_1-k_4 and f_i(RH) coefficients instead of using the original IMPROVE ones, which refer to aerosol properties measured at U.S. national parks.

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