Determination of the Heating Rate of black carbon at high time resolution: a new methodology for experimental measurements of source-identified radiative forcing effects

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Black carbon (BC) absorbs sunlight in the atmosphere heating it[1]. The heating rate (HR) can be determined from the divergence of the net radiative flux with altitude (vertical profiles) or from the modelling activity; however, it determination is, up to now, too sparse[2,3]. This work presents a new method to experimentally determine the HR induced by the absorptive component of aerosol. In urban context, it is essentially related to the BC. The methodology is based on the direct determination of the radiative power density absorbed into a ground-based atmospheric layer (a full set of physical equations will be discussed) determined coupling spectral aerosol absorption measurements with the spectrally resolved measurements of the direct, diffuse and reflected radiation; the spectral absorption of BC aerosol allows its source apportionment (traffic and biomass burning (BB)) allowing the same apportionment on HR.

One year (2015) of high-time resolution measurements (5 min) of sunlight absorption and HR induced by BC aerosol over Milan was investigated using: 1) Aethalometer (AE-31, Magee Scientific, 7-λ), 2) Multiplexer-Radiometer-Irradiometer (downward diffuse, direct and reflected radiance: 350-1000 nm in 3648 spectral bands), 3) a meteorological station (LSI-Lastem), 4) condensation and optical particle counters (TSI 3775 and Grimm 1.107), 5) low volume sampler (FAI Hydra, $PM_{2.5}$ and PM_{10}).

Results allowed to determine: 1) the mean monthly values of HR along one year (i.e. October: 1.04±0.01 K/day of HR, 3.0±0.1 μg/m^3 of BC) together with the high time resolution behaviour (Figure 1); 2) the importance of the direct, diffuse and reflected radiation on the HR (i.e. October HR: 0.42±0.10 K/day for direct, 0.44±0.10 K/day for diffuse, 0.18±0.10 K/day for reflected); 3) the daily cycle of BC and radiation; 4) the influence of anthropogenic activity (i.e. September HR: 1.00±0.06 K/day for working days, 0.35±0.02 K/day for non-working days); 5) determine the radiative effect of traffic and BB sources of BC: i.e. traffic BC for 1-15 and 15-31 October was 1.3±0.1 μg/m^3 and 2.3±0.1 μg/m^3 respectively, while BB BC was 0.7±0.1 μg/m^3 and 1.5±0.1 μg/m^3. In terms of HR, traffic BC for 1-15 and 15-31 October contributed with 0.46±0.01 K/day and 0.74±0.02 K/day while BB BC was 0.28±0.01 K/day and 0.61±0.02 K/day. All of the aforementioned results will be discussed using the full set of data collected.
of BC concentration.

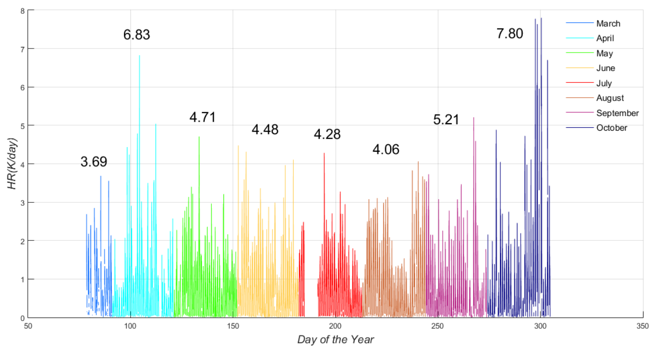

Figure 1. Heating rate values at high time resolution from March to October 2015. Maximum values of HR for each month are reported.

References:

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