

Supplement off:

The impact of cloudiness and different cloud types on the atmospheric heating rate of black and brown carbon

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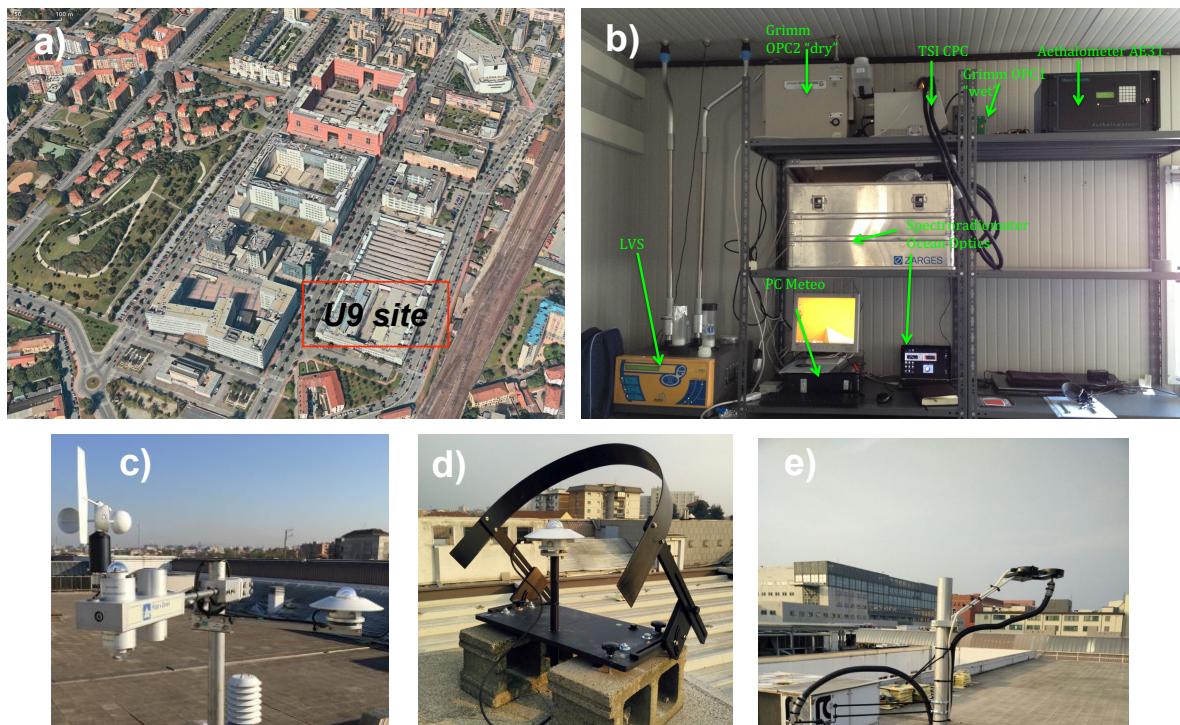


Figure S1. a) location of the U9 sampling site at the University of Milano-Bicocca; b) inner view of the site and of the instrumentation present there; c) Kipp&Zonen and LSI-Lastem radiometers (global, reflected), thermo-hygrometer and anemometer; d) LSI-Lastem radiometer and shadow-band for diffuse radiation; e) MRI (Multiplexer-Radiometer-Irradiometer) with rotating shadow-band. The copyright holder of panel a) is GoogleMaps (©GoogleMaps).

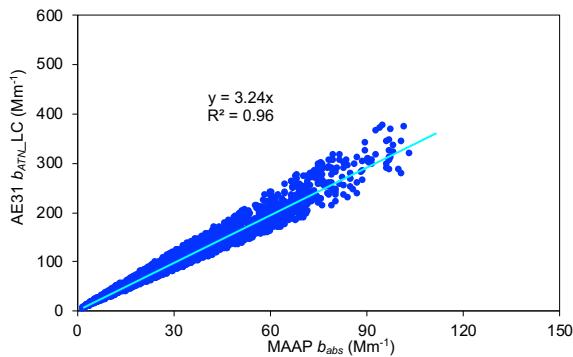


Figure S2. Linear correlations between the attenuation coefficient at 660 nm, yet loading corrected ($b_{ATN_LC,660nm}$ following Weingartner et al., 2003; section 2.2) from the AE31 Aethalometer and the MAAP absorption coefficient at the same wavelength.

N	0	1	2	3	4	5	6	7	8
a_0	-112.6	-112.6	-107.3	-97.8	-85.1	-77.1	-71.2	-31.8	-13.7
a_1	653.2	686.5	650.2	608.3	552.0	511.5	495.4	287.5	154.2
a_3	174.0	120.9	127.1	110.6	106.3	58.5	-37.9	94.0	64.9
a	0.73	0.72	0.72	0.72	0.72	0.70	0.70	0.69	0.69
L	-95.0	-89.2	-78.2	-67.4	-57.1	-45.7	-33.2	-16.5	-4.3

Table S1. The empirical coefficients relating the global radiation, at a fixed solar elevation angle ($\pi/2-\theta$), with the sky conditions (N, in oktas) extracted from the original work of Ehnberg and Bollen (2005).

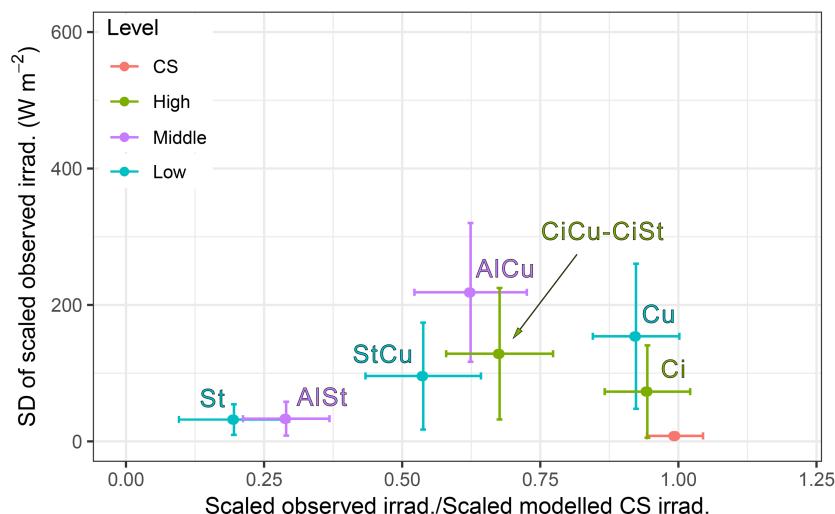


Figure S3. Cloud classification based on the improved broadband solar radiation following Duchon & O'Malley (1999) and Harrison et al. (2008) coupled with lidar data of cloud base height. From left to right: Stratus (St), Altostratus (AlSt), Stratocumulus (StCu), Altocumulus (AlCu), Cirrocumulus and Cirrusstratus (CiCu-CiSt), Cumulus (Cu), Cirrus (Ci), and finally clear-sky (CS). The SD-R plot reports centroids and standard deviation of each cloud type which are plotted in a color scale related to the cloud base level.

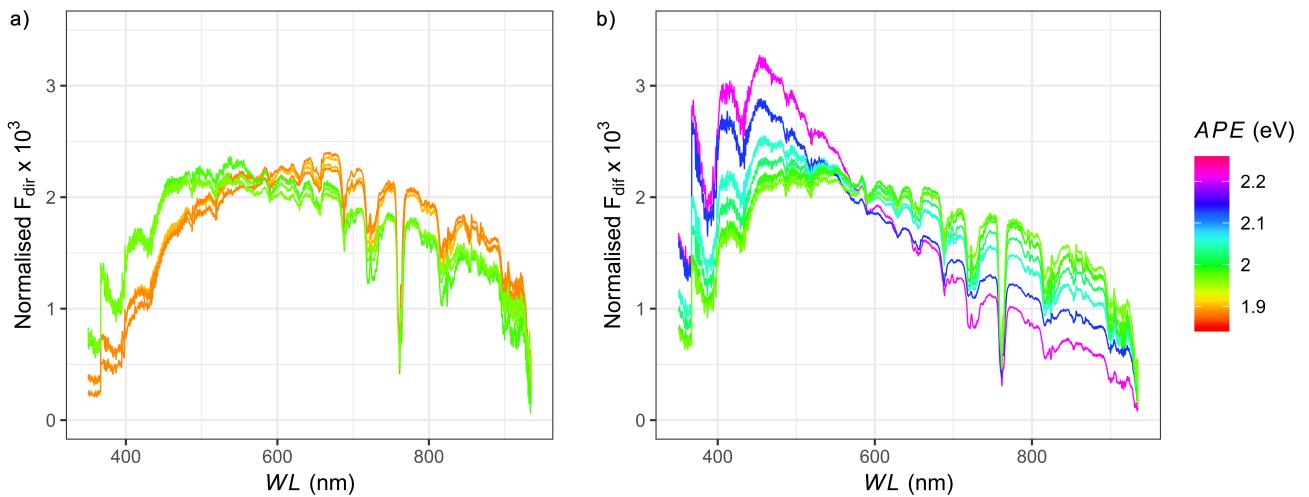


Figure S4. Average photon energy of different shape of radiation spectra for a) the direct and b) the diffuse radiations.

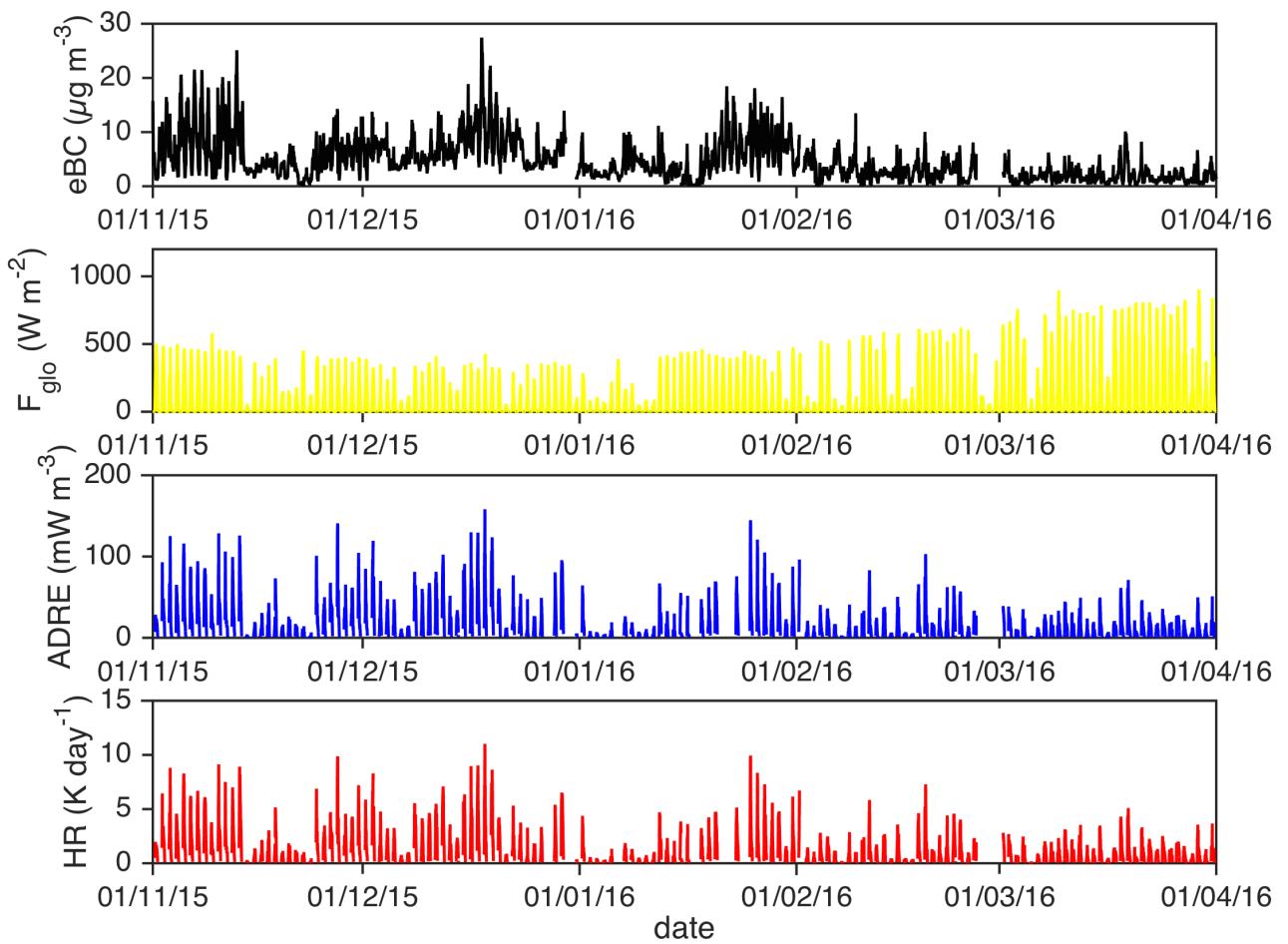


Figure S5. 5-min resolution data for eBC, global irradiance (F_{glo}), absorptive direct radiative effect (ADRE) and the related heating rate (HR).

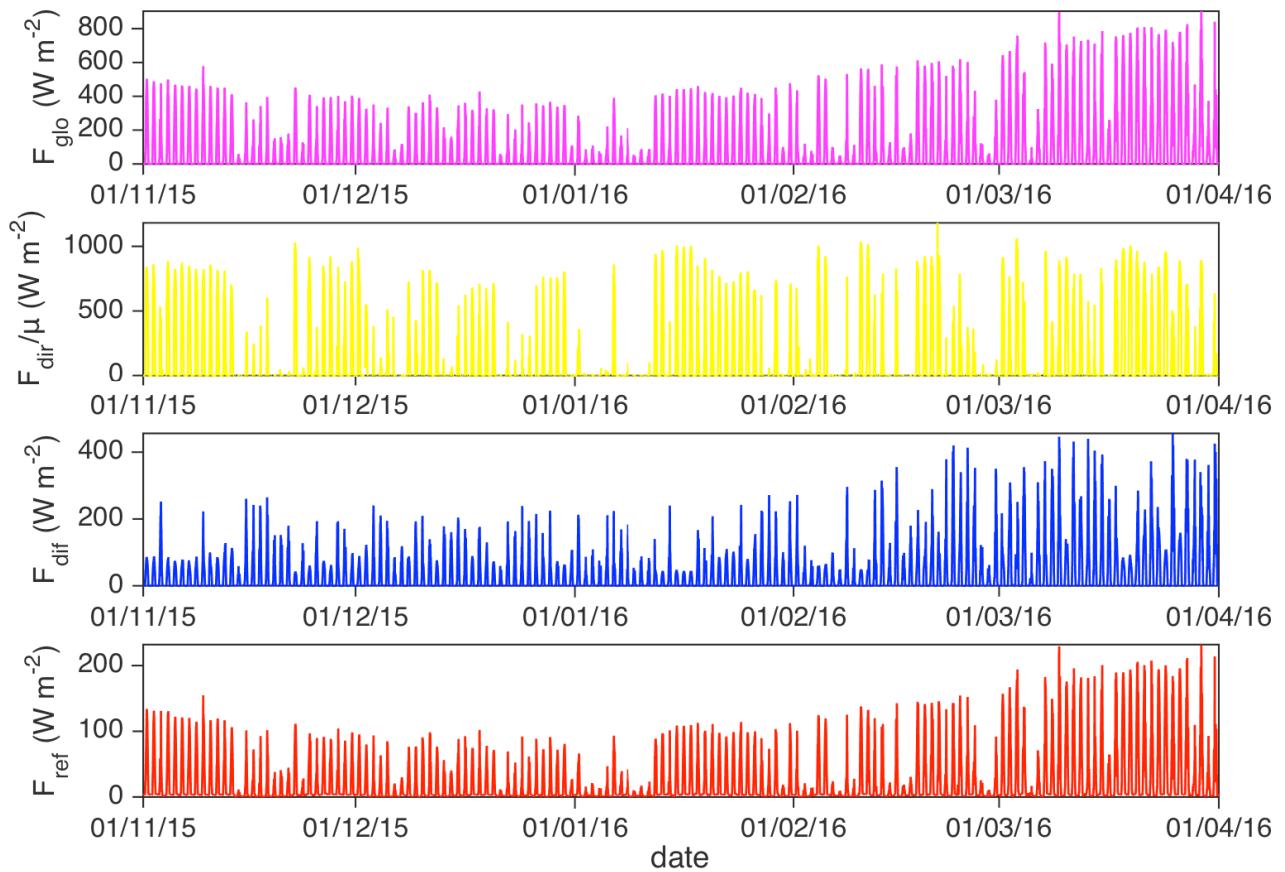


Figure S6. 5-min resolution data for the global radiation values (F_{glo}) and their direct, diffuse and reflected components (F_{dir}/μ , F_{dif} and F_{ref}). Once F_{dir} is scaled by μ (eq. 1, section 2.1) it is quite constant along the year and it is perfectly constant only in clear sky conditions. Conversely, the diffuse and reflected radiation, even when scaled by μ (under the isotropic and Lambertian assumptions), linearly follow the behavior of irradiance F_{dif} and F_{ref} .

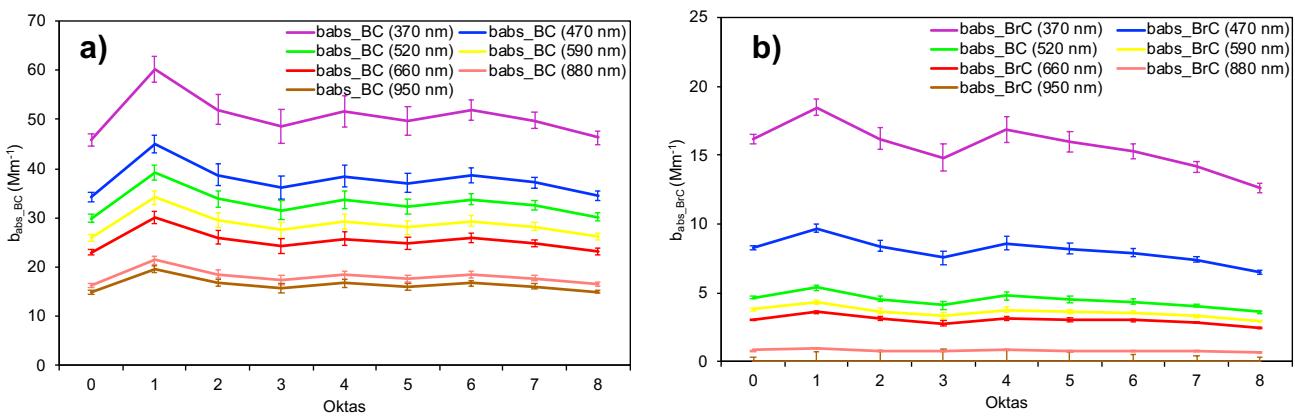


Figure S7. $b_{abs(\lambda)}$ values at the aethalometer 7- λ for both BC and BrC in function of the sky cloudiness expressed in oktas.

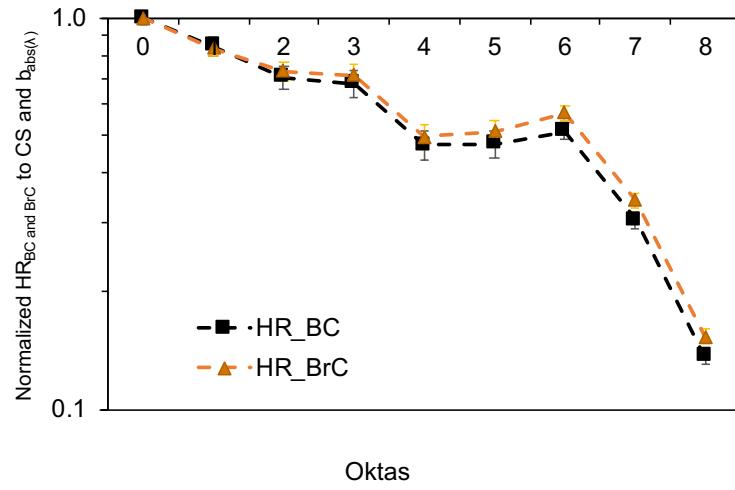


Figure S8. HR of BC and BrC in function of the oktas normalized by $b_{\text{abs}(\lambda)}$ and to the HR values in CS conditions.

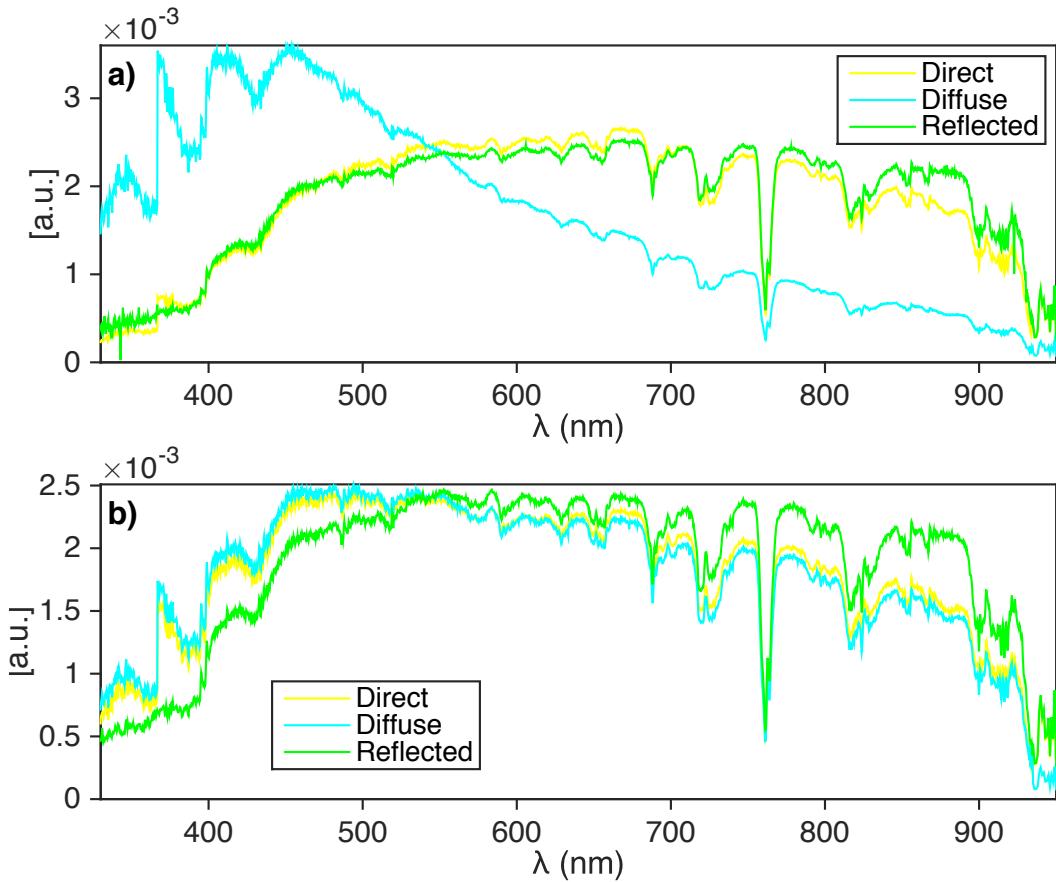


Figure S9. Normalized (integral equal to unity) spectra for direct (yellow), diffuse (cyan) and reflected (green) radiation in a clear sky (a) and in a cloudy (b) case.