# Jury is still out on the radiative forcing by black carbon

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LETTER

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Peng et al. (1) conclude that a fast increase in the mass absorption cross-section (MAC) of black carbon (BC) in urban environments leads to significantly increased estimates of the BC radiative forcing (RF). Their chamber measurements are highly valuable and complement observations performed in ambient conditions, but their "enhancement factor" relative to an unspecified baseline may not be directly comparable to values used or simulated in global aerosol models. MAC, a key parameter in our understanding of the net BC climate impact, is indeed a more relevant quantity to examine. A fast MAC enhancement in polluted environments as the BC gets coated with organic and inorganic species is consistent with recent findings (2, 3). Global models used in AeroCom [table S1 in Peng et al. (1), ref. 4] have an average MAC of ~8 $m^2 \cdot g^{-1}$ at 550 nm. This value is reflecting reported measurements, although there is a large spatial and seasonal variability in ambient MAC for aged particles, with values of ~10 $m^2 \cdot g^{-1}$ at a rural Northern Chinese site (2) (at 678 nm); 6–14 $m^2 \cdot g^{-1}$ at rural, urban, and high-altitude Indian locations (5) (at 678 nm); and ~6 $m^2 \cdot g^{-1}$ at an Arctic site (6) (at 522 nm).

Coating of BC by soluble species not only enhances absorption of solar radiation but also reduces the BC atmospheric lifetime (7). Fig. 1 shows an offset between the increase in average MAC value with faster BC aging and an overall shorter BC lifetime, resulting in a near-constant BC aerosol absorption optical depth and RF with aging time. Furthermore, current global aerosol models frequently have a too long BC lifetime and consequently overestimate BC concentrations downwind from source regions (8).

According to Peng et al. (1), their BC absorption enhancement factor of 2.4 is also an upper bound, only reached after 5 (Beijing) to 18 (Houston) h, and possibly longer in cleaner environments. Such timescales are not small compared with the BC atmospheric lifetime of 3–5 d, especially considering that dilution effects may lengthen the aging timescale in the real atmosphere compared with the static chamber measurements performed by Peng et al. It is unclear how representative these measurements are for global and annual averages, but we know that generalizations can introduce serious errors due to spatial and temporal sampling issues (9). This implies that a simple scaling of the BC RF by the absorption enhancement factor measured by Peng et al.—as performed by the authors in their table S1 and figure 4, and extended in the commentary (10)—is overly simplistic.

In conclusion, although we welcome the advances made by Peng et al., their conclusion of a +0.45 [0.21–0.80] $W \cdot m^{-2}$ additional RF due to a large BC enhancement factor is premature. The jury is still out on the question of the net climate impact of BC and how much climate cobenefit will result from the necessary mitigation of BC emissions. Reducing the uncertainty on the BC forcing requires better constraining BC MAC and atmospheric lifetime in global aerosol models.

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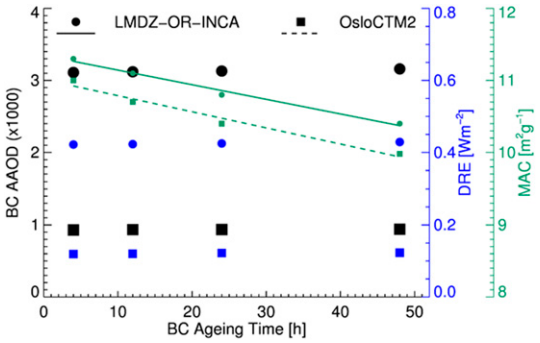


**Fig. 1. Relationship between BC aerosol absorption optical depth (AAOD) (black scale), MAC (green scale), and direct radiative effect (blue scale) as a function of the aging timescale of the BC aerosol in two different models: LMDz-OR-INCA and OsloCTM2. LMDz-OR-INCA includes all sources of BC; its MAC at 550 nm is 5.5 $m^2 \cdot g^{-1}$ for fresh BC increasing to an average of 11.4 $m^2 \cdot g^{-1}$ for aged BC, and the BC atmospheric residence time is about 6 d. OsloCTM2 includes fossil fuel and biofuel BC sources only; its MAC at 550 nm is 7.3 $m^2 \cdot g^{-1}$ for fresh BC increasing to 11.0 $m^2 \cdot g^{-1}$ for aged BC, and the BC atmospheric residence time is about 3 d (resulting in a better agreement with observations in remote regions). The BC enhancement factors are 2.1 and 1.5, respectively, but correspond to different baselines.**


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