LETTER

REPLY TO BOUCHER ET AL.:

Rate and timescale of black carbon aging regulate direct radiative forcing

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Peng et al. (1) quantify aging and variation in the optical properties of black carbon (BC) particles representing ambient urban conditions in developed and developing countries. There are several key implications in the findings of Peng et al. Under polluted environments, rapid aging and highly enhanced absorption of BC particles (by a factor of 2.4 within a few hours) contribute importantly to atmospheric stabilization and a diminished diurnal variation of the planetary boundary layer, likely exacerbating formation of severe haze events and modifying weather in China (2–6). The work by Peng et al. also reveals that the positive direct radiative forcing (DRF) of BC particles is highly dependent on the rate and timescale of aging, which are currently unaccounted for in global climate models (GCMs). Furthermore, the results by Peng et al. provide reconciliation of the conflicting results of highly variable BC absorption enhancement and mass absorption cross-section (MAC) measurements from the previous studies (1). Gustafsson and Ramanathan (7) comment that "Peng et al. assess the implications on climate by the constrained coating-enhancement of BC absorption" and "if this were to be confirmed by forthcoming studies, also focusing on properties of aged aerosols most relevant to large-scale effects, this will close the factor of 2–3 gap between model predictions and observations on the effect of BC aerosols on climate." In contrast, Boucher et al. (8) argue that "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." We noticed that there exist several confusing views in the Letter by Boucher et al. First, the authors claim that "their 'enhancement factor'. . .may not be directly comparable" and "it is unclear how representative," but point out that "a fast MAC enhancement. . .is consistent with recent findings" (8). Indeed, the consistency in the recent atmospheric measurements at different global locations confirms that the results by Peng et al. are applicable to diverse environmental conditions (7). Boucher et al. indicate that "there is a large spatial and seasonal variability in ambient MAC values for aged particles" but fail to recognize that the work by Peng et al. offers an explanation for the observed variation in MAC globally. They incorrectly state that "their BC absorption. . .is also an upper bound" (8). Furthermore, they notice the times of 5 (Beijing) to 18 (Houston) hours to achieve the BC absorption enhancement factor of 2.4 reported by Peng et al. (1), but their statement that "such timescales are not small compared to the BC atmospheric lifetime of 3–5 days" is conflicting. Apparently, BC is hydrophobic when fresh but becomes hydrophilic during atmospheric aging (9, 10), which regulates the atmospheric lifetime or aging timescale (1). On the basis of their atmospheric measurements and the available GCM simulations, Peng et al. provide a reasonable evaluation of the BC DRF, that is, 0.77 $W{\cdot}m^{-2}$ (0.36–1.37 $W{\cdot}m^{-2}$ reflecting the model uncertainty) (1). Nevertheless, we agree with Boucher et al. that reducing climate uncertainty requires precise representation of the BC MAC and lifetime in GCMs, and the results by Peng et al. provide the important constraint and guidance for future studies.

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