

Atmos. Chem. Phys. Discuss., referee comment RC1  
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## Comment on acp-2021-336

Anonymous Referee #1

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Referee comment on "Method to quantify black carbon aerosol light absorption enhancement with a mixing state index" by Gang Zhao et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2021-336-RC1>, 2021

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In this paper, the authors proposed a method to quantify light absorption enhancement for black carbon (BC) aerosols by considering entropy and diversity. The authors indicated that the mass ratio (MR) of non-BC coating thickness to BC (MR) and particle-to-particle heterogeneity represent two key parameters in regulating the radiative absorption enhancements by BC. They introduced a BC mixing state index ( $\chi$ ) to quantify the dispersion of BC mixing states based on a binary system of BC and non-BC components. They showed that the BC light absorption enhancement increases with  $\chi$  for the same MR, indicating that  $\chi$  can be employed as a factor to constrain the light absorption enhancement of ambient BC. This work proposed a novel framework to treat BC light absorption enhancement, which can be useful to study BC radiative effects in climate models. The paper was reasonably written, but some effort is still necessary to improve its readability. I recommend publication of this paper in ACP, provided that the following issues have been adequately addressed.

### Major points

- (1) The title needs to be modified, since it is unclear how their framework is obviously linked to "entropy and diversity measures"
- (2) The authors argued that the BC light absorption enhancement is dominantly determined by two physical parameters, i.e., MR and  $\chi$ . However, there are several studies showing that the chemical properties of the coating materials, i.e., organic versus inorganic species, are also critical in regulating the morphology and optical properties. For example, coating of sulfuric acid has been shown to be more efficient in altering the BC morphology and light absorption (e.g., Variability in morphology, hygroscopic and optical properties of soot aerosols during internal mixing in the atmosphere, Proc. Natl. Acad. Sci. USA 105, 10291, 2008). Such an aspect needs to be discussed in the context of their proposed framework.
- (3) It would be desirable that their proposed framework can also be compared to other experimental studies, particularly those relevant to different chemical species (Enhanced light absorption and scattering by carbon soot aerosols internally mixed with sulfuric acid, J. Phys. Chem. 113, 1066, 2009; Effects of dicarboxylic acid coating on the optical properties of soot, Phys. Chem. Chem. Phys. 11, 7865, 2009).
- (4) Also, I believe that their proposed framework deals exclusively with dry particles.

Under atmospheric conditions, aerosols (particularly for those containing high level of inorganic species) likely experience hygroscopic growth at high relative humidity (RH), which inevitably impacts their morphology and optical properties. How such an issue could be addressed by their method.

(5) A recent work showed BC-catalyzed sulfate formation (An unexpected catalyst dominates formation and radiative forcing of regional haze, Proc. Natl. Acad. Sci. USA 117, 3960, 2020), which is primarily responsible for their optical properties under polluted conditions. How would the BC aging processes, i.e., reactive (catalyzed) versus physical (condensation/partitioning) would impact their proposed framework?

Minor suggestions.

Improvement in English is still necessary. I identified some grammar errors below.

Line 13, replace "its" by "the".

Line 14, delete "thickness".

Line 149, add a conjunction between two parallel sentences.